Dynamic Financial Analysis in the Insurance Industry

A Study of Current Practices, Determinants of Company Performance, and Application of Dynamic Financial Analysis

Yung-Ming Shiu

PhD
The University of Edinburgh

2004

Abstract

Dynamic Financial Analysis (DFA) has become one of the important tools that actuaries use to model the underwriting and investment operations of insurance companies. This thesis investigates two major related issues concerning the application of DFA, including the current practices of DFA/ Dynamic Solvency Testing (DST)/ Financial Condition Reports (FCR), and the performance determinants that should be considered being included in DFA/DST applications.

The empirical research presented in this thesis is based on the non-life and life postal surveys that were administered in May 2002, interviews conducted with some of the survey respondents, and statutory returns filed by UK insurers to the supervisory authority. The principal conclusions of this thesis are: (1) the proportion of life offices using financial modelling techniques and FCR is greater than that of their non-life counterparts, and with-profit offices tend to use more techniques and are more capable of doing sophisticated asset modelling than their non-profit counterparts, (2) *lack of need* is the main reason why these techniques and FCR are not commonly used in the non-life sector, and (3) *liquidity*, *unexpected inflation*, and *interest rate level* are determinants of general insurer performance, whereas *company size* is a determinant of life office performance.

Moreover, a number of differences between the non-life and life offices are identified. First, non-life insurers conduct scenario testing on a more frequent basis than life offices. Second, most of the risk categories tested in non-life scenarios are related to underwriting operation, whereas those in life scenarios are related to investment operation. Third, life offices generally use a longer projection period in DST/business plan than their non-life counterparts in DFA/business plan. Finally, the projection periods in DFA and business plan are significantly correlated in non-life insurance, whereas this correlation between DST and business plan is not found in life insurance.

Table of Contents

List of Tables

List of Figures

Declaration

I declare that the contents of this thesis have been composed entirely by myself, that the work contained is my own, and that all contributions from others have been clearly indicated and have been given due reference.

Yung-Ming Shiu

Acknowledgements

I am indebted to my supervisors Dr. Peter Moles and Dr. Andy Adams for their support during my studies. My examiners Professor Richard Verrall and Dr. Jake Ansell offered insightful and valuable comments on this thesis, for which I am most grateful. Thanks are also due to Dr. Peter England, Dr. John Banasik, Ms. Florence Grant and Ms. Yvonne Murrey for many useful discussions.

Further thanks are due to the Ministry of Education, Taiwan for the sponsorship of postgraduate studies. I would also like to acknowledge the Faculty and Institute of Actuaries (Memorial Education and Research Fund Award) and the University of Edinburgh Development Trust (Small Project Grant) for their financial assistance which made part of the empirical analysis of this research possible.

Finally, thanks go to my family for their support and encouragement all these years. Without their love and understanding, the thesis would not have been possible.

Chapter One

Introduction

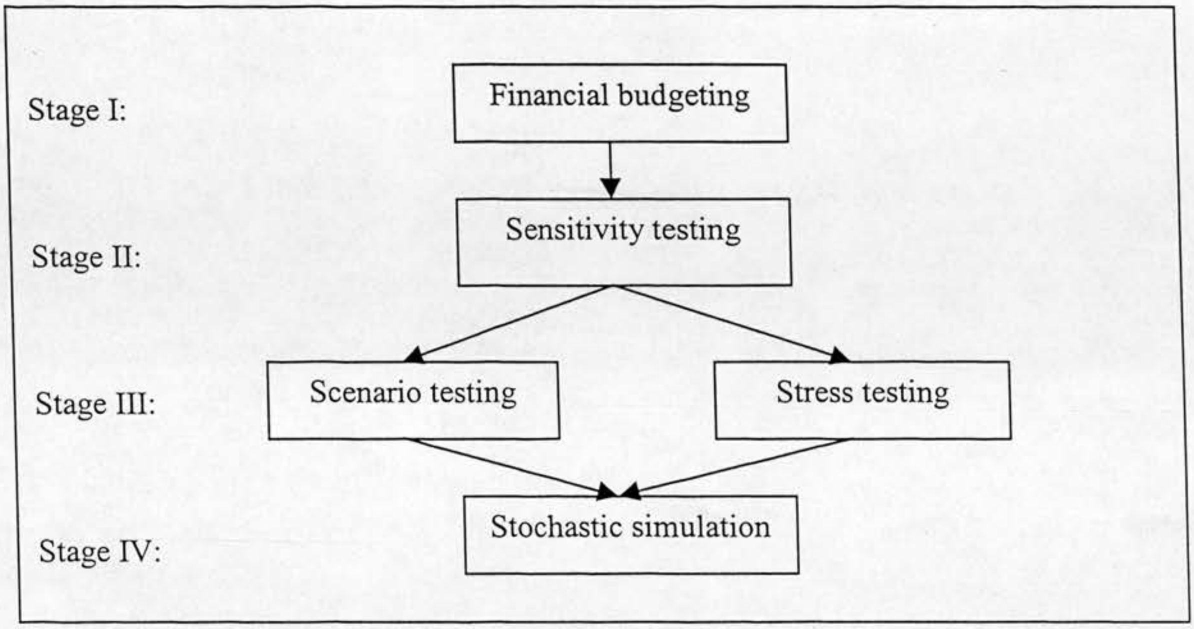
Dynamic Financial Analysis (DFA) has become one of the important tools that actuaries use to model the underwriting and investment operations of insurance companies. More and more actuarial professional bodies across the world provide guidelines to help actuaries evaluate the financial condition of their individual companies using DFA or its variants. Since there has been a recent trend among insurance regulatory authorities towards adopting risk-based approaches to regulating insurance business, insurance companies currently not using DFA will probably adopt something along the lines of DFA in the near future. This thesis investigates two major related issues concerning the application of DFA, including the current practices of DFA/ Dynamic Solvency testing (DST)/ Financial Condition Reports (FCR), and the performance determinants which should be considered being included in DFA applications. It is worth noting that DST is a variant of DFA specifically applied in solvency testing and FCR is the output of DFA/DST. In this thesis, DFA is sometimes used as the generic term for the various types of related applications such as DST.

1.1 The Evolution of Financial Modelling Techniques and Dynamic Financial Analysis

1.1.1 The Evolution

In order to evaluate the financial impact of a wide variety of risks on their financial condition, financial institutions utilise and adapt financial modelling techniques which have been developing in the financial world over the years. These techniques evolve from simple financial budgeting, which can be considered of a static nature to complicated financial modelling, which has a dynamic nature. As illustrated in Figure 1.1, at least four stages of this evolution can be identified.

Figure 1.1: The evolution of financial modelling techniques



Stage I: Financial budgeting

In essence, financial budgeting is a static model which projects the future financial condition of the company based on one set of assumptions. Its projection is actually only one path into the future. For instance, the company can project its surplus for the next five years based on one set of assumptions on assets, liabilities and economic conditions, and other key factors.

Stage II: Sensitivity testing

Unlike financial budgeting whose projection is only one path into the future, sensitivity testing, also known as sensitivity analysis, expands the projection by projecting a number of paths into the future. Sensitivity testing is the simplest form of the so-called "what-if" analysis. It is usually conducted by changing one key variable at a time. By carrying out a series of calculations it is possible to build up a picture of the nature of the risks facing the company and the impact of these risks on financial performance.

Stage III: Scenario testing and Stress testing

Like sensitivity testing, scenario testing is also a "what-if" analysis. The difference between the two is that sensitivity testing is conducted by changing one variable at a time whereas scenario testing is carried out by changing a group of variables at a time. It should be noted that these variables are usually assumed in a consistent way. Scenario testing projects financial condition using a number of scenarios usually including, at least, a worst-case and a best-case scenario.

Stress testing is an extreme case of scenario testing and involves the worst and most unusual scenarios. If the financial condition of the company under these extremely rare scenarios is still tolerable, then the risks are in general assumed to be acceptable.

Stage IV: Stochastic simulation

The concept of stochastic simulation is often incorporated into the scenario building process of scenario testing. In this case, stochastic simulation is used for generating a huge number of scenarios and can be regarded as a form of scenario testing. The difference between stochastic simulation and ordinary scenario testing mentioned above is that the values for the variables in the scenarios established in stochastic simulation are randomly selected from the probability distributions assumed, whereas those in ordinary scenario testing are predetermined deterministically. The scenarios established using stochastically simulated values for the variables are referred to as stochastic scenarios whereas those established using predetermined values for the variables are referred to as deterministic scenarios[1].

---

[1] Further discussion about stochastic simulation and scenario testing can be found in Section 3.3 of Chapter three.

In the course of evolution, at least two trends in the development of financial modelling techniques can be identified. First, the nature of financial modelling techniques changes from deterministic to stochastic. Second, current approaches place more emphasis on the interrelationship between the variables in question.

1.1.2 What is Dynamic Financial Analysis?

DFA is a process whereby an actuary analyses the financial condition of an insurance company. Financial condition refers to the ability of the company's capital and surplus to adequately support the company's future operations through an unknown future environment[2]. The Casualty Actuarial Society (2000) defines DFA as a systematic approach to financial modelling in which financial results are projected under a variety of possible scenarios, showing how outcomes might be affected by changing internal and/or external conditions. DFA can also be defined in terms of its uses as follows: DFA is one of the tools, which can be used to quantify the financial effect of likely future economic situations, and to evaluate the financial impact of implementing different management strategies on the financial performance of a company.

Strictly speaking, DFA is not a new approach to financial modelling and its basic principles and concepts are very similar to those in asset-liability management (ALM), which has been employed in the insurance and banking industries for many years. It is difficult to draw a distinction between DFA and ALM. Christofides (2000) implicitly suggests that DFA models have better economic scenario generators than traditional asset-liability models. Kaufmann et al. (2001) point out that DFA is applied almost exclusively to property-casualty insurance especially in North America, whereas an extremely similar concept in life insurance is still called ALM. Moreover, Cumberworth

[2] See Szkoda et al. (1995). This definition of financial condition is from the investors' or shareholders' point of view. From the insurance regulator's point of view, financial condition of an insurance company can be defined as its prospective ability to meet its obligations to policyholders, members and those to whom it owes benefits. See Canadian Institute of Actuaries (1998).

et al. (2000) simply regard DFA as ALM[3]. To sum up, it is safe to say that DFA is a variant of ALM, and it seems that greater emphasis is placed on both economic scenario generators and the interrelationships between assets and liabilities in DFA models than in relatively traditional ALM models. This can be further confirmed by the comments of D'Arcy et al. (1998) on DFA:

"*It (DFA) provides a far more effective tool for forecasting future financial and operating conditions of an insurance company than prior methods for two primary reasons. First, the interactions between the underwriting and investment sides of the insurance business are formally integrated. Second, this approach utilises advances in computer technology and modelling techniques to provide almost instantaneous feedback to decision makers, allowing for the evaluation of numerous operating alternatives.*"

1.1.3 The Uses of Dynamic Financial Analysis

The uses of DFA are extremely extensive and the examples cannot be exhaustive. Some of the main uses are summarised below:

1. Test the solvency status of an insurer and assess its financial strength under a wide range of adverse economic and operating scenarios.
2. Evaluate different management strategies such as reinsurance programmes, asset allocation, and merger and acquisition.
3. Determine the amount of capital allocated to business units.
4. Determine the amount of surplus allocated to lines of business.

---

[3] It appears to me that Gorvett (1998) regards DFA as ALM as well, although he does not clearly indicate this. In his research, he points out that DFA became important to the insurance industry mainly because of the increased levels and volatility of interest rates in the last several decades. He further points out that the DFA process was embraced by the life insurance industry many years before it became an important topic in the property-liability insurance industry. Besides, the life insurance industry did embrace the idea of ALM earlier than the property-liability insurance industry because the former is more exposed to interest rate risk than the latter.

Moreover, DFA is also very helpful to an insurer in the following ways. First, it can be used to help develop the business plan by identifying the potential external and internal threats to company operations. Second, the results of DFA can be used to communicate with rating agencies. Besides, rating agencies possibly award a relatively favourable rating to a company whose management is aware of the threats to their company operations. Third, it can be used to evaluate how much an insurer would charge for its policies (i.e. price its products) under a range of likely future economic and financial conditions. Table 1.1 presents some of major applied DFA research classified in terms of DFA use. The DFA techniques used in these papers are also shown in this table.

Table 1.1: Research Regarding the Application of Dynamic Financial Analysis

Use of DFA	Researcher	Technique
Solvency testing	Ryan (1984)	Stochastic simulation
	Daykin et al. (1987)	Stochastic simulation
	Muir and Sarjant (1997)	Deterministic scenario testing
	Mango (2000)	Stochastic simulation
	Philbrick and Painter (2001)	Stochastic simulation
Evaluation of reinsurance programmes	Burkett, McIntyre and Sonlin (2001)	Stochastic simulation
Asset allocation	Almagro and Sonlin (1995)	Stochastic simulation
	Correnti, Sonlin and Isaac (1998)	Stochastic simulation
	Kaufman and Ryan (2000)	Stochastic scenario testing
	Burkett, McIntyre and Sonlin (2001)	Stochastic simulation
	Christofides and Smith (2001)	Stochastic simulation
Capital Allocation	Mango and Mulvey (2000)	Stochastic simulation
	Philbrick and Painter (2001)	Stochastic simulation
	Christofides and Smith (2001)	Stochastic simulation
Surplus allocation	Hodes, Feldblum and Neghaiwi (1999)	Deterministic scenario testing and stochastic simulation
	Olsen (2001)	Stochastic simulation

1.2 Dynamic Financial Analysis and Insurance Companies: Some History

Like other financial institutions, insurance firms have been utilising and adapting these above-mentioned financial modelling techniques to meet their needs. For instance, scenario testing has been extensively used by insurers for quite a long period of time before it is formally introduced into the process of monitoring solvency. This method is known as DST. DST involves projecting the assets and liabilities of an insurance company under a variety of hypothetical scenarios to investigate the susceptibility of its fund to unfavourable experience of different kinds.

In practice, since 1992 valuation actuaries of life insurance companies operating in Canada have been conducting DST in accordance with the Standard of Practice on Dynamic Solvency Testing for Life Insurance Companies issued by the Canadian Institute of Actuaries (1991). According to the Canadian Institute of Actuaries (1993), this Standard of Practice also had been applied to the Appointed Actuaries of fraternal benefits societies since 1994. In 1999 the Standard of Practice on Dynamic Solvency Testing was replaced by the Standard of Practice on Dynamic Capital Adequacy Testing. Based on the latest Standard of Practice, all Appointed Actuaries of insurance companies operating in Canada are required by the Superintendent of Financial Institutions to conduct Dynamic Capital Adequacy Testing (DCAT) and prepare financial condition reports.

In the UK, a Working Party under the auspices of the Joint Actuarial Working Party was set up in 1993 to consider whether DST should be formally introduced into the process of monitoring the solvency of life insurance companies and whether a financial condition report should be prepared and made available to the insurance regulatory authority. In 1996 the Faculty and Institute of Actuaries issued Guidance Note 2 (GN2). According to GN2 Appointed Actuaries responsible for long-term insurance business are encouraged to prepare FCR using DST.

Generally speaking, DST and DCAT in Canada use scenario testing of a deterministic nature. There are ten deterministic scenarios suggested in the Canadian DST for initial testing, including worsening mortality, morbidity and withdrawal rates, increasing and decreasing interest rates, level and high new sales, sudden worsening in mortality and morbidity, and increased default and expense rates. The Standard of Practice on DCAT lists 10 and 11 risk categories for life and non-life insurance companies and suggests that at least three plausible adverse scenarios posing the greatest risk to the company require scenario testing and reporting annually. As for the UK, GN2 lists four assumptions that "there would need to be specific reasons for not testing", eight assumptions that "may be of considerable importance in some companies but not others", and ten assumptions to which the Appointed Actuary needs to be alert. GN2 points out that it may be helpful, as a matter of routine, to test the effect of each assumption using sensitivity testing and that certain assumptions, in particular those which are a consequence of the economic environment, are best treated as a group using scenario testing.

The use of stochastic simulation in insurance can be traced back to the start of the 1980s. The work by Pentikäinen and Rantala (1982), members of the Finnish Solvency Working Party, was one of the first to use a stochastic model to assess solvency margins. Pentikäinen et al. (1989) developed a relatively complete stochastic model to demonstrate how to model the risks that may affect the financial position of insurance companies. In the UK, the Solvency Working Party of the General Insurance Study Group was set up at the end of 1982 in order to develop a similar approach that can be used in an UK context along the lines of the work of the Finnish Solvency Working Party. A number of relevant works using stochastic simulation was published afterwards including Ryan (1984), Daykin and Bernstein (1985), Daykin et al. (1987), Daykin et al. (1990), Hardy (1993), Macdonald (1995), Hardy (1996), Berketi (1998), and Consigli (1998).

1.3 The Aims of the Thesis

This thesis investigates two major issues regarding the application of DFA. First, what are the current practices of DFA/DST/FCR in insurance companies and friendly societies carrying on general and long-term business. Second, there are a number of economic and firm-specific factors which are presumed to have an impact on the financial performance of insurance companies and that should be considered being included in DFA/DST applications. It is worth noting that these two issues are related to the first two steps in conducting DFA. The whole process of carrying out DFA can be found in Section 3.2 of Chapter three. Moreover, existing models of insurance business range from very complex to relatively simple representations. Where, in this range, is the appropriate level to build a DFA model? What specific components, factors, and level of detail should be included in a DFA model? This thesis aims to investigate what components and factors are currently included in DFA related applications by practitioners and in what level of detail. Also, it presents some of the valuable insights emerging from this work, explaining and making more accessible those likely to be of interest to the actuary charged with the work of building a company-specific DFA model and the FSA. The thesis provides much of the information necessary for these two parties about what the practices are. After finding out the current industry practices, the actuary will be able to make an informed judgement on what components, factors, level of detail he or she should include in modelling. Also, the FSA will be kept informed of the developments in the industry and will be able to offer practical guidance to insurers for solvency monitoring purposes.

The purpose of the thesis is to address the above-mentioned interrelated issues. Two primary aims of the thesis are identified. The first is to investigate the current practices of DFA/DST/FCR in the UK insurance industry. Among other things, this includes the investigation of the risk categories included in DFA/DST applications and the importance of possible performance determinants rated by practising actuaries. The second aim is to identify which economic and firm-specific factors are important in determining the performance of UK insurance companies and should be carefully considered being included in DFA/DST models. After these two aims are achieved, the results obtained can be compared to examine whether the factors identified are included as risk categories in scenarios or whether they are considered important performance determinants. This can be regarded as an indicator of the soundness of actuaries' professional judgement.

Because of the nature of these issues, a number of research methods were used. First, two postal surveys were administered and questionnaires were distributed to Appointed Actuaries, Chief Actuaries or Finance Directors of UK insurance companies and friendly societies carrying on general and long-term businesses to investigate the current practices of DFA/DST/FCR. Moreover, semi-structured interviews were conducted with five respondents to the surveys in order to obtain further in-depth information as regards how DFA/DST related techniques were used within individual organisations. In addition, the interviewees' opinions on DFA/DST/FCR related issues were also elicited at the interview. Second, in order to identify the economic and firm-specific factors affecting company performance, econometric analyses were conducted using two panel data sets.

1.4 The Layout of the Thesis

The thesis begins with an introduction which describes the evolution of DFA related techniques and their relationship with insurers, with an emphasis on when and how UK insurers use these techniques. Then two issues related to DFA and the research methods used to address these issues are discussed.

The remainder of the thesis is organised as follows. Chapter two presents an overview of the UK industry and sets the stage for the empirical analyses in the latter chapters. The overview is concerned with insurance business and regulations in the UK, and the development and financial performance of the UK insurance industry during the period

1986-1999. Since the main theme of the thesis is concerned with DFA in the insurance industry, it is necessary to have a general picture of the industry itself. Moreover, this chapter also provides background information for the empirical analyses in Chapter eight, such as the likely determinants of company performance in the UK insurance industry. Different classifications of the risks faced by insurance companies are summarised. Finally, the current practices of DFA in the UK, the USA and Canada, and a number of relevant empirical surveys are reviewed. Based on the review of the current practices, one main area where further empirical research is required is identified.

In Chapter three, a number of important elements of DFA are discussed. First of all, the process of conducting DFA is outlined. Two main DFA techniques, scenario testing and stochastic simulation, are compared and their strengths and weaknesses discussed. Since driving factors and cascade structures are of particular importance in DFA models, especially those using stochastic simulation, they are illustrated in this chapter using two examples. The final section of this chapter identifies one more main area where further empirical research is necessary.

Chapter four reviews the literature on determinants of insurance company performance. The methodologies, dependent and explanatory variables employed in some important empirical studies are compared. Then ten commonly seen performance measures are discussed. Based on their theoretical relationship with performance, a number of possible economic and firm-specific factors are identified. The relevant hypotheses regarding the relationships between performance and these factors are formulated.

Chapter five formulates four research questions, and discusses the research paradigm and methodology which underpin the research undertaken. Due to the different nature of the research questions, three research methods are used in order to meet the aims of the thesis. Also, the rationales for the approaches taken are provided.

Chapter six presents the findings of two postal surveys designed to investigate the current practices of DFA/DST/FCR in the insurance industry. In order to examine whether the survey respondents may be regarded as representative of the survey population, the non-respondent bias test is conducted. The similarities and differences between the results for different types of insurance offered are presented and discussed.

Chapter seven presents the findings obtained from five interviews. These findings are intended to enrich the results of the postal surveys that have been presented in the previous chapter by providing a more in-depth account of the current practices of DFA/DST/FCR within the five organisations interviewed.

Chapter eight presents the findings of two empirical analyses aimed for identifying the determinants of company performance in the non-life and life sectors respectively. A number of hypotheses were tested using panel data sets consisting of economic data and FSA/DTI returns over the period of 1986-1999. Some econometric problems such as heteroskedasticity, multicollinearity and autocorrelation are also addressed in this chapter. Moreover, the results from the surveys and the econometric analyses are compared.

In conclusion, Chapter nine examines whether the aims of the research have been achieved, identifies the contributions of the research, summarises the findings, and provides advice for the industry and the future researchers in this filed.

Chapter Two

Overview of the UK Insurance Industry

2.1 Introduction

The purpose of this chapter is twofold: (1) to provide an overview of the UK insurance industry and (2) to set the stage for the empirical analyses in the latter chapters. This overview is concerned with insurance business and regulations in the UK, and the development and performance of the UK insurance industry during the period 1986 through 1999. A number of accounts of three consolidated financial statements, including technical account (revenue account), non-technical account (profit and loss account) and balance sheet, along with some key ratios and measures are utilised to examine the development of the industry and to compare the differences between the non-life and life sectors, where appropriate. In some cases where the comparability is not appropriate because of the particular account or ratio utilised, the individual sectors will be discussed separately using different but similar accounts or ratios.

This overview of the UK insurance industry is mainly based on statutory returns of 346 non-life insurance companies and 311 life insurance companies from 1985 through 1999 in the data sets of SynThesys Non-Life (Version 3.32) and SynThesys Life (Version 3.32)[1], unless stated otherwise. Appendix A reports consolidated technical account, non-technical account, balance sheet, and key ratios and measures of the UK non-life and life insurance sectors during the period under review. Besides, the definitions of accounts and ratios, and meaning of financial statements are also provided in the same Appendix. It should be noted that because this analysis is mainly focused on the UK insurance market, eight non-life insurance companies[2]

---

[1] The data sets of both SynThesys Non-Life (Version 3.32) and SynThesys Life (Version 3.32) are the products of Standard & Poor's Thesys.

[2] The eight companies include Everest Reinsurance Company Ltd, Mapfre Re Compania de Reaseguros SA, Middle Sea Insurance Co Ltd, Münchener Rückversicherungs-Gesellschaft, Odyssey America Reinsurance Corp, Transatlantic Reinsurance Co, UNUM Life Insurance Co of America (UK Branch) and XL Mid Ocean Reinsurance Co Ltd.

submitting global returns in the SynThesys Non-Life are excluded from this research[3].

In addition, insurance companies, as risk intermediaries, face a wide range of risks. It is important for the actuary who is in charge of conducting DFA to have a good understanding of the risks faced by the company. These risks will be classified and discussed in this chapter. This chapter also reviews the current DFA practices in the UK, the USA and Canada, and compares a number of empirical surveys regarding these practices.

The remainder of this chapter is organised as follows. Section 2.2 describes UK insurance business and regulations. Section 2.3 discusses the development of the UK insurance industry. Section 2.4 investigates the performance of the industry and its consolidated financial statements. Section 2.5 classifies and discusses the risks faced by insurance companies. Section 2.6 reviews the current practices of the application of DFA or its variants in the UK, the USA and Canada. The final section summarises and concludes this chapter, and a possible future research area based on the literature and practices reviewed so far is also suggested in the same section.

2.2 Insurance Business and Regulations in the UK

2.2.1 Insurance Business

Broadly speaking, there are two different kinds of insurance- general insurance and life insurance. General insurance is also known as non-life insurance, which means the business of general insurance companies. It should be noted that in this thesis general insurance and non-life insurance are used interchangeably. Life insurance is

[3] In the UK, there are three types of annual returns submitted to statutory authorities for supervisory purposes, including global return, UK branch return and EEA branches return. Global return reports the entire worldwide business of the insurance company. UK branch return reports only the business carried on through a branch in the UK. EEA branches return reports the entire business carried on through all branches in EEA states including the UK (Financial Services Authority, 1998). In the data set of SynThesys Non-Life (Version 3.32), there is no company submitting EEA branches return.

also referred to as long-term insurance, which means the business of life insurance companies.

Insurance companies have to be authorised whether by the regulator of the UK or another EEA Member State in order to carry on insurance business in the UK. Table 2.1 shows the number of insurance companies authorised as at 31 December of each year during the period 1983 through 2000.

Table 2.1: Number of insurance companies authorised as at 31 December of each year (1983-2000)

Year	General only	Life only	Composite	Total	All life	All general
1983	560	214	75	849	289	635
1984	561	221	71	853	292	632
1985	557	214	70	841	284	627
1986	550	215	69	834	284	619
1987	557	213	68	838	281	625
1988	564	209	65	838	274	629
1989	562	206	64	832	274	626
1990	570	203	64	837	267	634
1991	570	202	64	836	266	634
1992	565	196	62	823	258	627
1993	575	194	59	828	253	634
1994	573	191	57	821	248	630
1995	594	174	58	826	232	652
1996	578	177	59	814	236	637
1997	599	177	65	841	242	664
1998	594	176	62	832	238	656
1999	596	171	62	829	233	658
2000	597	165	60	822	225	657

Source: Insurance Annual Report 2000 (H M Treasury, 2001).

The results in the above table indicate that the underlying trend of the number of companies authorised to carry on general insurance business was upward during the period under review, whereas that of long-term insurance business downward. Besides, the trend of the number of composites which were authorised to carry on both general and long-term business was also downward. Since the increases in the number of general insurers were less than the decreases in long-term insurance firms and composites, the underlying trend of the total number of insurers was also downward.

1. General insurance (Non-life insurance)

According to Annex 11.2 to Chapter 11 of the Interim Prudential Sourcebook for Insurers of the FSA Handbook (Financial Services Authority, 2002b), general insurance business can be categorised into 18 classes. The previous table shows that the number of insurers authorised to carry on general insurance business in the UK as at 31 December 2000 was 657. Table 2.2 further presents the number of general insurers authorised for each class as at 31 December 2000.

Table 2.2: Number of general insurance companies authorised for each class as at 31 December 2000

Class	Description	Number
1	Accident	554
2	Sickness	462
3	Land vehicles	368
4	Railway rolling stock	406
5	Aircraft	391
6	Ships	418
7	Goods in transit	494
8	Fire and natural forces	468
9	Damage to property	475
10	Motor vehicle liability	353
11	Aircraft liability	392
12	Liability for ships	417
13	General liability	467
14	Credit	386
15	Suretyship	469
16	Miscellaneous financial loss	520
17	Legal expenses	439
18	Assistance	144

Source: Insurance Annual Report 2000 (H M Treasury, 2001).

These 18 classes are further classified into the following eight groups: accident and health, motor, marine and transport, aviation, fire and other damage to property, liability, credit and suretyship, and general. Table 2.3 shows the groups of classes of general insurance business.

Table 2.3: Groups of classes of general insurance business

Group	Description	Class
1	Accident and health	Classes 1 and 2.
2	Motor	Classes 1, 3, 7, and 10.
3	Marine and transport	Classes 1, 4, 6, 7 and 12.
4	Aviation	Classes 1, 5, 7 and 11.
5	Fire and other damage to property	Classes 8 and 9.
6	Liability	Classes 10,11,12 and 13.
7	Credit and suretyship	Classes 14 and 15.
8	General	All classes.

Source: Interim Prudential Sourcebook for Insurers of the FSA Handbook (Financial Services Authority, 2002b).

The above table shows that the classes are not limited to one group. For instance, Class 1 (Accident) is included in Groups 1 (Accident and health), 2 (Motor), 3 (Marine and transport) and 4 (Aviation).

2. Long-term business (Life insurance)

According to Annex 11.1 to Chapter 11 of the Interim Prudential Sourcebook for Insurers of the FSA Handbook (Financial Services Authority, 2002b), long-term business can be classified into nine categories: life and annuity, marriage and birth, linked long-term, permanent health, tontines, capital redemption, and pension fund management, collective insurance, and social insurance. As indicated in Table 2.1, the number of insurance companies authorised to carry on long-term insurance business in the UK as at 31 December 2000 was 225. Table 2.4 further shows the number of long-term insurance companies authorised for each class as at 31 December 2000.

Table 2.4: Number of long-term insurance companies authorised for each class as at 31 December 2000

Class	Description	Number
I	Life and annuity	223
II	Marriage and birth	154
III	Linked long term	213
IV	Permanent health	199
V	Tontines	0
VI	Capital redemption	150
VII	Pension fund management	169
VIII	Collective insurance	0
IX	Social insurance	0

Source: Insurance Annual Report 2000 (H M Treasury, 2001).

As the above table shows, there were no insurance companies authorised to carry on tontines, collective and social insurance as at 31 December 2000. The main types of UK long-term insurance contracts are briefly described below.

(1) Term insurance

A term insurance contract provides pure insurance protection. This contract pays an agreed sum of benefit if the life assured dies within a specified period, also known as the "term". If the life assured is still alive at the end of the term no benefit is paid. Since the insurer may not have to pay the benefit, term insurance contract costs far less than other types of long-term insurance contracts which provide not only insurance protection but savings. These insurance contracts that include a saving or investment element are also referred to as cash value insurance contracts, including whole life insurance, endowment insurance and annuities.

(2) Whole life insurance

A whole life insurance contract pays an agreed sum of benefit whenever the life assured dies. Since the life assured is mortal, the agreed sum of benefit must be paid at some time in the future and as a result the premium rates for whole life insurance are more expensive than those for term insurance given the same sum insured.

(3) Endowment insurance

An Endowment insurance contract can be regarded as the combination of term insurance and pure endowment. This contract pays an agreed sum of benefit either following the death of the life insured or upon the survival of the life insured to the end of the term.

(4) Annuity

An annuity contract starts to pay benefits to the annuitant on an agreed date. From that date benefits are paid on a regular basis for the rest of the life of the insured. Annuity contracts can be divided into two categories: immediate and deferred annuities. An immediate annuity contract starts to pay benefits since the premium is paid, whereas a deferred annuity contract only pays benefits at an agreed later date.

The above-mentioned UK long-term insurance contracts are often issued with many different features. Based on the features, these contracts can be divided into two categories such as non-profit versus with-profit contracts, or non-linked versus linked contracts. Non-profit contracts, also known as non-participating contracts, are traditional life insurance contracts that are not allowed to participate in the profits earned by the fund, whereas with-profit contracts known as participating contracts are allowed to participate in the profits. Compared to non-profit contracts, with-profit contracts provide a lower sum insured for a given amount of premium but their benefits are increased because of the distribution of bonuses. There are two types of bonuses in the UK: reversionary and terminal bonuses. The former are usually distributed annually and added to the maturity value of the contracts. The amount of reversionary bonuses, usually expressed as some proportion of the sum insured, depends on the investment and underwriting performance of the life insurance company. Once declared, reversionary bonuses cannot be taken away.

Compared with reversionary bonuses, a terminal bonus is paid at the claim date and is one-off.

Linked contracts, also known as unit-linked contracts, are life insurance contracts whose premiums less expenses are invested in a designated asset fund. The policyholder's share of the fund is referred to as unit fund. The value of the unit fund will increase or decrease depends on the value of the asset fund. That is, the policyholder's returns are directly related to the returns on the investments to which they are stated to be linked (e.g. UK or foreign equities). There are two main types of linked contracts: property and index linked contracts. Property linked contracts confers property linked benefits whereas index linked contracts confers index linked benefits. Life insurance contracts where the proceeds are not linked to specific assets are categorised as non-linked contracts.

2.2.2 Insurance Regulations

1. Insurance legislation

Before 1 December 2001, a date widely referred to as "N2", the Insurance Companies Act 1982 and the Regulations made thereunder mainly defined the regulatory regime for insurance companies[4]. Some of the most important Regulations included the following:

(1) The Insurance (Lloyd's) Regulations 1983 (Statutory Instrument 1983 No. 224) which dealt with matters regarding the business of Lloyd's.
(2) The Insurance Companies Regulations 1994 (Statutory Instrument 1994 No. 1516) which dealt with margins of solvency, conduct of business, the valuation of assets, and the determination of liabilities, etc.
(3) The Insurance Companies Regulations 1996 (Statutory Instrument 1996 No. 943) which prescribed the forms of statutory returns.

[4] To be more specific, before "N2" insurance companies were regulated under the Insurance Companies Act 1982, and friendly societies under the Friendly Societies Act 1992. Life insurance companies' conduct of business was regulated under the Financial Services Act 1986.

(4) The Insurance Companies Regulations 1996 (Statutory Instrument 1996 No. 946) which made provision for the purposes of section 34A of the Insurance Companies Act 1982 (general business: equalisation reserve).

(5) The Insurance (Lloyd's) Regulations 1996 (Statutory Instrument 1996 No. 3011) which clarified certain aspects of the regulatory arrangements for members and former members of Lloyd's, and updated the prescribed form of returns.

Since 1 December 2001 the FSA has become the UK single statutory financial services regulator responsible for regulating all financial services including insurance business. On that date the provisions of the Financial Services and Markets Act 2000 (FSMA) came into full effect, and those of the Insurance Companies Act 1982 and the Regulations made thereunder were repealed. All the activities of insurance companies are now governed by the FSMA and other legal instruments such as the FSA Handbook of Rules and Guidance (the Handbook). This Handbook consists of six blocks: high level standards, business standards, regulatory processes, redress, specialist sourcebooks, and special guides. It is worth mentioning that the second block of the Handbook contains five Interim Prudential Sourcebooks including the Interim Prudential Sourcebook for Insurers. It is noted that the majority of the past provisions of insurance company regulations can be found almost unchanged in the Interim Prudential Sourcebook for Insurers, particularly in respect of the Forms of the statutory returns to be submitted by insurance companies. However, there is a significant change regarding the filing period allowed for the submission of the returns. Under Sections 17 (Annual accounts and balance sheets) and 22 (Deposits of accounts etc. with Secretary of State) of the Insurance Companies Act 1982, insurance companies were required to deposit the returns with the statutory regulator within six months from the end of the financial year. The period of six months can be extended by up to three months if the Secretary of State approves it. Nevertheless, under the Accounts and Statements Rules which are set out in Chapter nine of Interim Prudential Sourcebook for Insurers, this filing period has now been shortened for the financial year ending on or after 31 December 2001 to four months if the deposit is made electronically, or three months and 15 days if made manually. Moreover, for the financial year ending on or after 31 December 2002 the filing period is further reduced to three months, and two months and 15 days respectively. The primary reason for reducing the filing period is to enable the FSA to identify adverse trends and threats to company solvency as soon as possible.

2. Insurance regulator

Under the Insurance Companies Act 1982 and Regulations made thereunder, the statutory regulator of insurance business was formerly the Insurance Division of the Department of Trade and Industry. From 5 January 1998 the Insurance Directorate of HM Treasury took over, and assumed the regulatory powers and responsibilities. Before the main provisions of FSMA came into force, there was an interim measure. The functions (in relation to insurance) of the Insurance Directorate were contracted out to the FSA. That is, the FSA had actually exercised the functions of insurance supervision before the FSMA came into effect in 2001.

- Risk-based approach to supervision

In the past, the FSA's prudential regulation of insurance tended to be too reactive and relied on desk-based analysis of returns. The FSA currently adopts a more proactive and challenging risk-based approach to supervision of insurance companies (Financial Services Authority, 2001b). This approach mainly follows the Basel Accord, which is focused on banking supervision. The latest proposal for a New Basel Capital Accord issued by the Basel Committee on Banking Supervision in January 2001 is based on three pillars: minimum capital requirements, a supervisory review process and effective use of market discipline. In respect of capital adequacy, the Committee states that (Basel Committee on Banking Supervision, 2001):

"*The new framework is intended to align capital adequacy assessment more closely with the key elements of banking risks and to provide incentives for banks to enhance their risk measurement and management capabilities*."

The FSA sets four regulatory objectives including (1) maintaining market confidence, (2) promoting public understanding of the financial system, (3) securing consumer protection, and (4) the reduction of financial crime. The risk-based approach to supervision aims to achieve these four objectives. This can be confirmed by the following quotation from the Supervision Manual of the FSA Handbook (Financial Services Authority, 2002):

"*The purpose of taking a risk-based approach to supervision is to focus the FSA's resources on the mitigation of risks to the regulatory objectives, and to have regard to the need to use the FSA's resources in the most efficient and economic way. The approach to risk assessment of firms is based on the extent to which they pose risks to the FSA meeting the regulatory objectives. .... This approach permits a matching of the intensity of the FSA's supervisory effort with the degree of risk posed by firms to meeting the regulatory objectives.*"

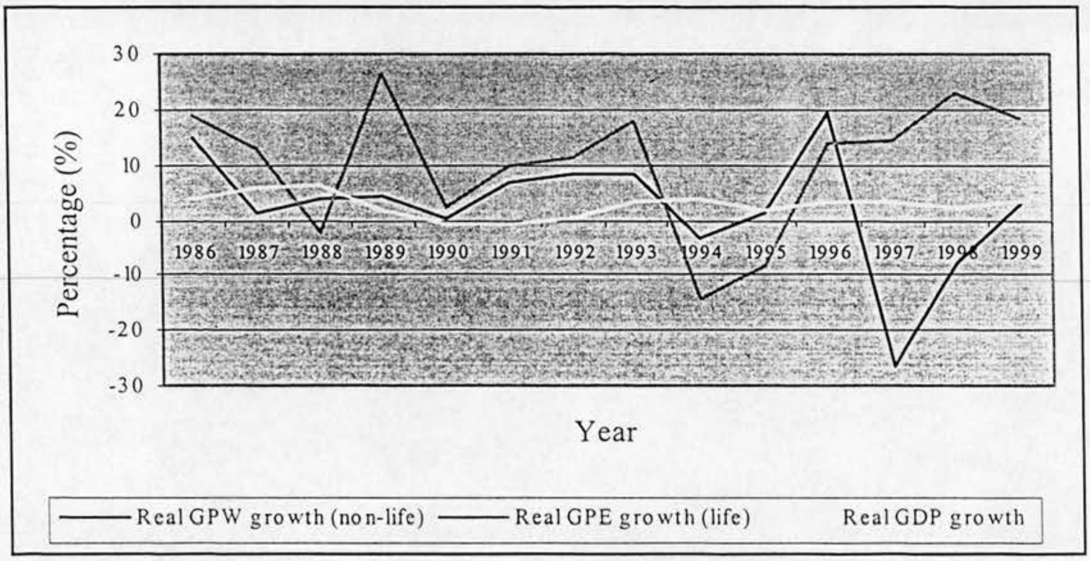
It is worth mentioning that there are, at least, two new requirements relating to the risk-based approach to regulation of insurance companies. First, insurance companies should have adequate financial resources to meet policyholders' claims. An increased emphasis is placed on the identification and management of risks relative to the adequacy of technical provisions and the solvency margin. Second, insurance companies should demonstrate that they have adequate financial resources to meet policyholders' claims. Insurance companies are required to use stress tests and scenario analysis to assess whether they have enough financial resources to meet liabilities (Financial Services Authority, 2001a).

2.3 The Development of the UK Insurance Industry

1. Real growth rates of premiums and gross domestic product[5]

Premium income is vital for the survival and profitability of insurance companies[6]. Figure 2.1 shows the real growth rates of gross premiums written (GPW) of non-life insurance business, gross premiums earned (GPE) of life insurance business[7], and gross domestic product (GDP)[8] during the period 1986 through 1999.

Figure 2.1: Real growth rates of gross premiums written, gross premiums earned and gross domestic product (1986-1999)



[5] The real growth rates of premiums and gross domestic product (GDP) are the growth rates of nominal premiums and GDP after adjustment for inflation. To remove the effect of inflation and obtain real premiums and GDP, nominal premiums and GDP are respectively divided by Retail Price Index (RPI), which is the main domestic measure of inflation in the UK. The effect of inflation is removed in order to determine whether the increases in premiums and GDP reflect the increases in overall prices or the increases in the demand for insurance and in the output. Real growth rates of premiums and GDP are measured as [(Real premiums)$_t$ – (Real premiums)$_{t-1}$ / (Real premiums)$_{t-1}$] * 100% and [(Real GDP)$_t$ – (Real GDP)$_{t-1}$ / (Real GDP)$_{t-1}$] * 100% respectively. Besides, the data source of RPI is National Statistics (Office for National Statistics, 2001a).

[6] Because of the importance of premium income insurance companies sometimes engage in the so-called "cash-flow underwriting", an underwriting practice where coverage is provided for a premium level that is actuarially less than necessary to pay claims and expenses. The insurance company that engages in cash-flow underwriting believes that it can make an investment profit on the premiums to compensate for the underwriting loss.

[7] There are two reasons why GPW of the non-life insurance business and GPE of the life insurance business are utilised as the indicators of premium volumes for the two industries respectively, although GPW and GPE are not the same. First, they are available in the returns of non-life and life insurance companies respectively. Second, it is reasonable to assume that GPW and GPE of the particular industry grow proportionately. Therefore, real growth rates of GPW and GPE should be comparable.

[8] The data source of GDP is United Kingdom National Accounts- The Blue Book (Office for National Statistics, 2001b).

Real growth rate of GPW ranged from –26.2 per cent (minimum) in 1997 to 19.3 per cent (maximum) in 1996 and averaged 2.4 per cent during this period under review. It has been positive except in 1994, 1997 and 1998. Real growth rate of GPE ranged from –14.3 per cent (minimum) in 1994 to 26.6 per cent (maximum) in 1989 and averaged 10.3 per cent during this period under review. It has been positive except in 1988, 1994 and 1995. Real growth rate of GDP ranged from –0.9 per cent (minimum) in 1990 to 6.4 per cent (maximum) in 1988 and averaged 2.7 per cent during the period under review. It has been positive except in the years of 1990 and 1991.

Codoni (2000) points out that non-life insurance business in all regions across the world has on average risen either in line with or to a greater degree than GDP over the past twenty years. In the UK, the average growth rate of GPW of non-life insurance was slightly smaller than that of GDP during the period under review. Increasing competition among financial service providers to attract funds could be one of the reasons why real GPW growth rate sometimes did not catch up with real GDP growth rate.

It is also noted that real GPW growth rate had an abrupt decrease in 1997. In fact, in that year non-life insurance business dramatically shrank not only in the UK but also in other parts of Western Europe. The sudden decrease in real GPW growth rate is attributable to falling premium rates because of the effects of deregulation in the European Union (EU) market (Helfenstein, 1999; Codoni, 2000). Falling premium rates indicate intense price competition resulting from the switch from price and product control to solvency control, and the opening up of national insurance market within the countries of the EU[9].

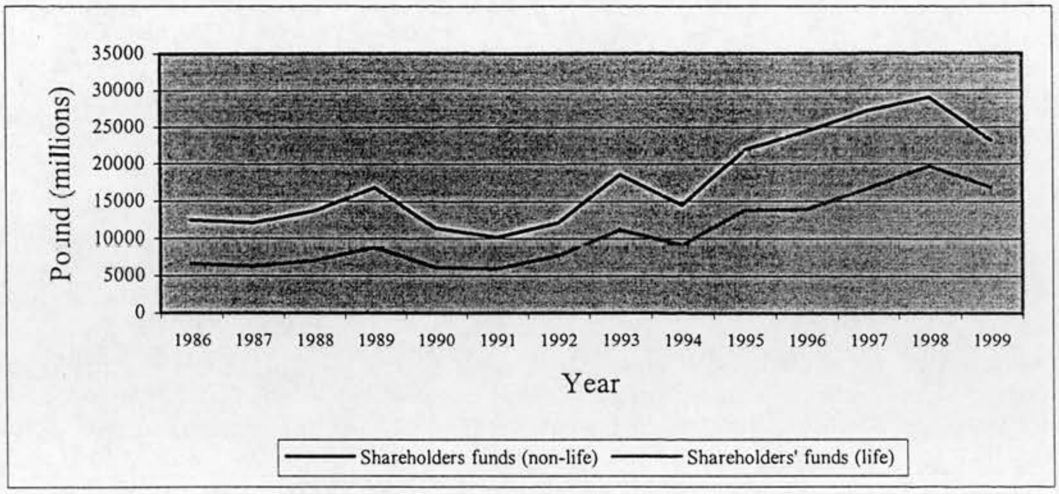
[9] The measures of deregulation and opening up of insurance markets in the EU were in response to the Third Insurance Directive whose main features include the abolition of price and product control, single insurance licences and home country control in the EU insurance market. See Birkmaier and Helfenstein (2000).

Compared to non-life insurance business, life insurance business had far stronger but more volatile growth. Figure 2.1 shows that the growth of the life business had consistently outperformed that of the non-life business over almost the entire period except in 1988, 1994, 1995 and 1996. It is worth noting that life business grew faster than non-life business mainly because of relatively low interest rates and increasingly important role played by life insurance companies in private pension provision. It is also noted that life business growth has been maintained at high levels after 1996 was partly because the good performance of equity market resulted in soaring demand for unit-linked insurance products. Besides, the reason why life business was relatively volatile is in part due to the fact that demand for life insurance is very sensitive to changes in the economic and market conditions (Helfenstein, 1999; Codoni, 2000).

2. Shareholders' funds

Shareholders' funds serve as a financial cushion and last resort to policyholders. Figure 2.2 shows that the trends of shareholders' funds of the UK insurance industry during the period of 1986 through 1999. In this period under review, shareholders' funds of non-life insurance business were on average about 1.7 times those of life insurance business. Moreover, shareholders' funds in the two businesses had moved in a similar way. Besides, it is noted that from the mid-1990s shareholders showed confidence in the insurance industry and continuously injected capital into insurance companies, non-life insurers in particular, in spite of the underperformance of the non-life industry compared to other industries. Thus the capital of insurers was significantly increased. Since the capacity of insurers is primarily determined by the amount of capital that they can commit to underwriting a portfolio of loss exposures (Troxel and Bouchie, 1995), the significantly increased capital led to excess capacity of insurance companies. Excess capacity has become one of the main characteristics of the UK non-life insurance industry.

Figure 2.2: Shareholders' funds of the UK insurance industry (1986-1999)



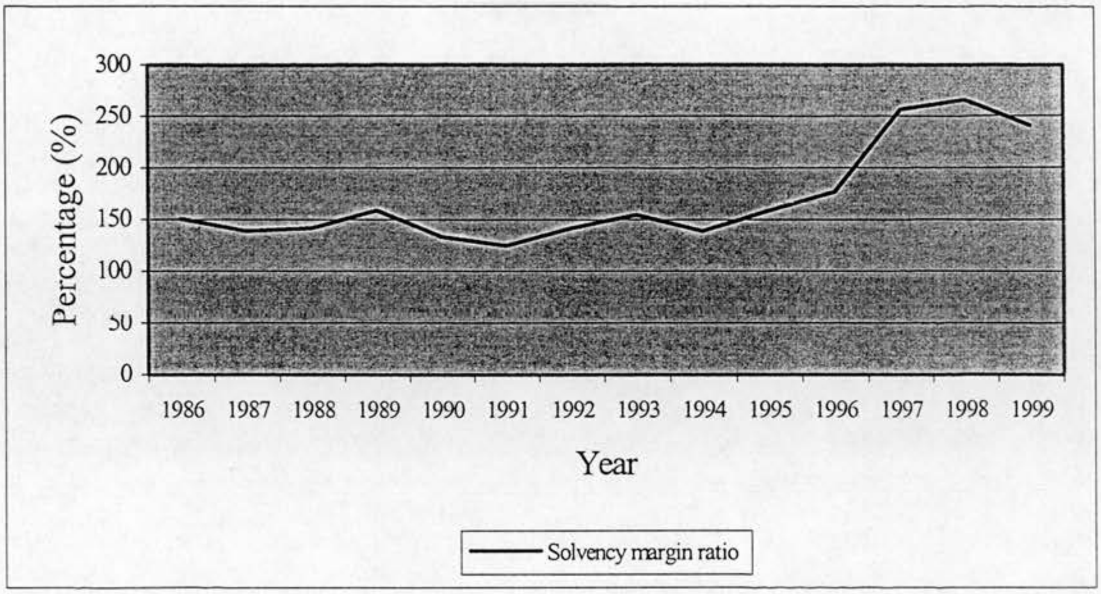
3. Solvency margin ratio and free asset ratio

Solvency margin ratio[10] and free asset ratio[11] are indicators of financial strength commonly used in non-life and life insurance sectors respectively. The solvency margin ratio of non-life business ranged from 124.6 per cent (minimum) in 1991 to 265.9 per cent (maximum) in 1998 and averaged 170.1 per cent during the period under review. Figure 2.3 shows that the solvency margin ratio had roughly remained at around 150 per cent during the period 1986 through 1995. Since 1996, it had been dramatically increasing until 1998.

[10] Solvency margin ratio is defined as (Net assets/ Net premiums written)*100%.

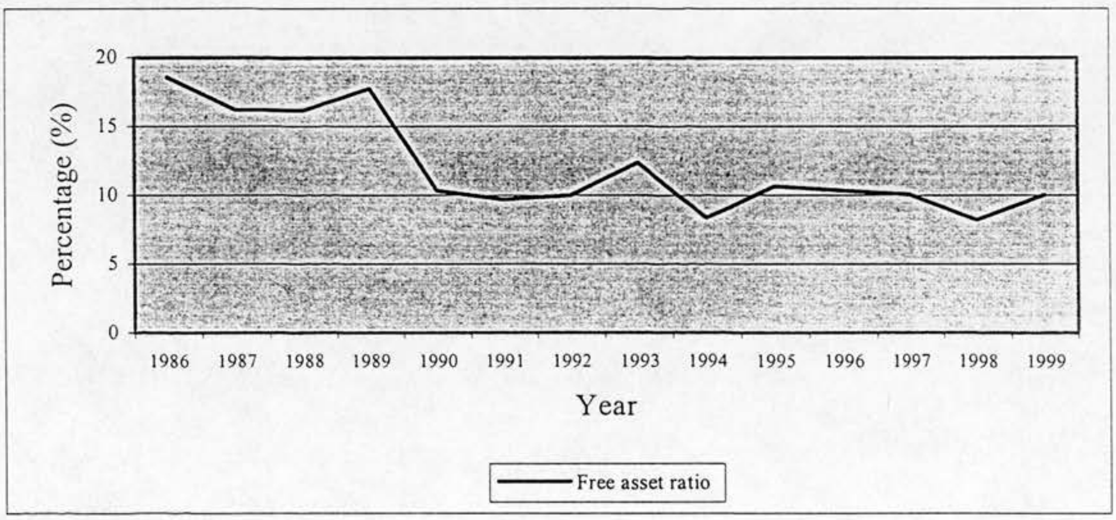
[11] Free asset ratio is defined as (Excess of available assets and implicit items over the required minimum margin / long term business admissible assets) * 100%. This definition is based on required minimum margin and is frequently used in the insurance industry. As to the commonly seen definition used in other industries, it is based on liabilities and is defined as (Excess of assets over liabilities / assets) * 100%.

Figure 2.3: Solvency margin ratio of the UK non-life insurance industry (1986-1999)



The free asset ratio of life business ranged from 8.2 per cent (minimum) in 1998 to 18.6 per cent (maximum) in 1986 and averaged 12.4 per cent during the period under review. Figure 2.4 shows that the free asset ratio had been decreasing and maintained at around 10 per cent since the start of 1990s.

Figure 2.4: Free asset ratio of the UK life insurance industry (1986-1999)



2.4 The Performance of the UK Insurance Industry

In this section, some important accounts of the three above-mentioned consolidated financial statements and performance measures are utilised to investigate and compare the performance of the UK non-life and life insurance sectors. The important accounts include underwriting profit and changes in funds in the technical account (revenue account), pre-tax profit in the non-technical account (profit and loss account), and asset allocation in balance sheet. The performance measures include percentage change in shareholders' funds, return on shareholders' funds, and investment yield.

2.4.1 Technical Account (Revenue Account)

Underwriting profit and changes in funds[12] are two summary statistics of underwriting performance used in the technical account of non-life business and in the revenue account of life business respectively. The underwriting profit ranged from –£6,380.1 million (minimum) in 1991 to £148.3 million (maximum) in 1994 and averaged

that underwriting profit had been negative since 1986, except in 1994 when insurance companies collectively made a small profit, reflecting the poor underwriting performance of non-life insurance industry over these years.

Figure 2.5 also shows that there was a complete underwriting cycle starting from 1988 to 1994. The cycle length was about six years, which is roughly consistent with the findings of Enz and Karl (2001)[13] that the average length of the underwriting cycle of the UK non-life insurance market is 6.1 years.

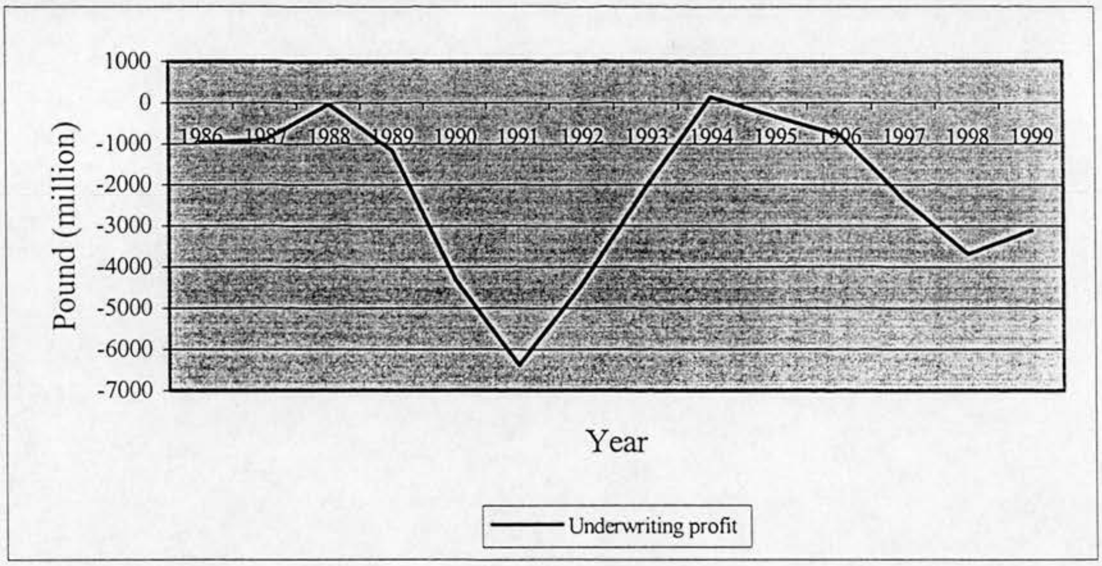
The latest underwriting cycle reached its trough in 1998 when shareholders' funds reached historically high levels (Figure 2.2), which led to downward pressure on

[12] See Appendix A.2 for the definitions of underwriting profit and changes in funds.

[13] Enz and Karl (2001) use the premiums to claims ratio as a dependent variable and the UK data from 1969 through 2000 to test for underwriting cycle. This ratio of premiums to claims is considered to be a measure of the aggregate economic value of insurance (Frech and Samprone, 1980).

premium rates. After 1998, the UK non-life insurance market was hardening[14] and underwriting results improved. Non-life insurance companies have been able to increase premium rates or implement a stricter underwriting process in order to improve underwriting results and accordingly to achieve better profitability. Besides, it is also noted in Figure 2.5 that the trough of the latest underwriting cycle starting from 1994 is apparently smaller than that of the previous one lasting from 1988 to 1994.

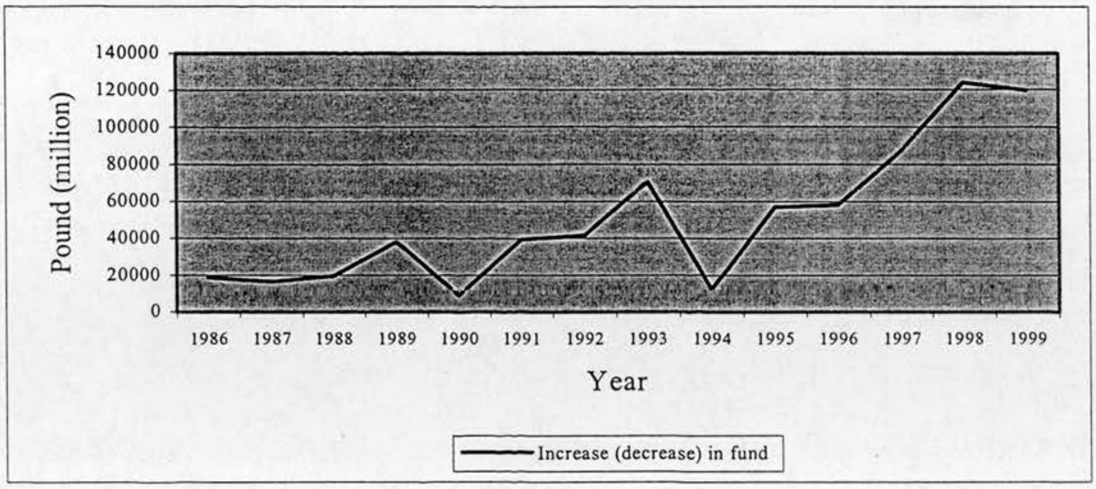
Figure 2.5: Underwriting profit of the UK non-life insurance industry (1986-1999)



Changes in the funds of life business ranged from £9,158.7 million (minimum) in 1990 to £124,018.5 million (maximum) in 1998 and averaged £50,963.1 million during the period under review. Figure 2.6 shows that the increase in funds had been taking place since the beginning of the 1990s. The sharp increase in recent years mainly reflected the good performance of financial markets.

[14] Hard market means that premium rates are high; soft market means that premium rates are low.

Figure 2.6: Changes in funds of the UK life insurance industry (1986-1999)



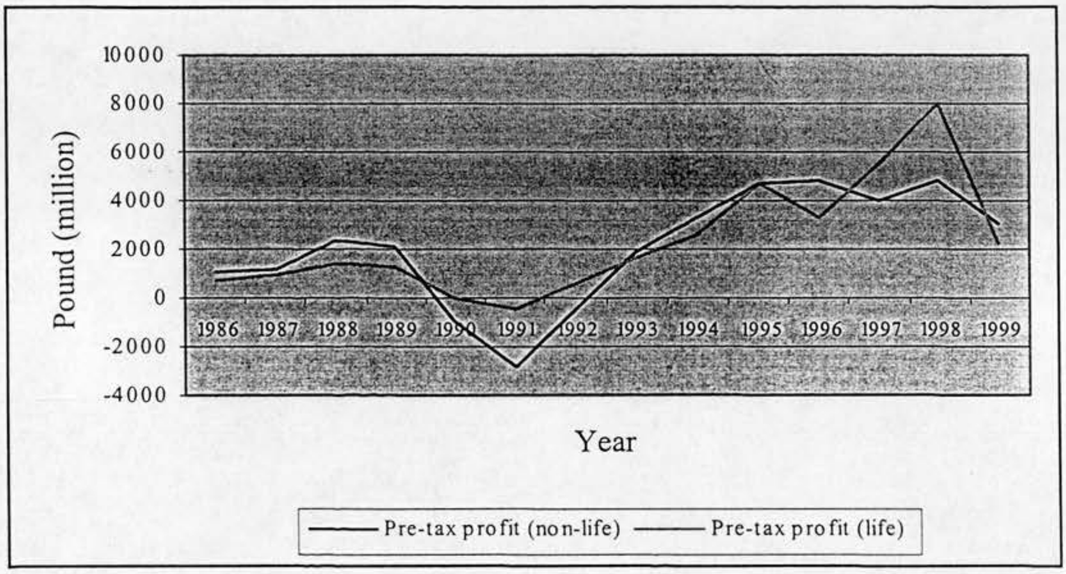
2.4.2 Non-technical Account (Profit and Loss Account)

Since taxation could be different in different industries pre-tax profit is often used as one of the indicators to compare the profitability between industries. Figure 2.7 shows the trends of pre-tax profit of the UK insurance industry during the period 1986 through 1999. In this period under review, pre-tax profits of non-life and life insurance have moved in a broadly similar way.

The pre-tax profit of non-life business ranged from –£2,844.6 million (minimum) in 1991 to £4,806.1 million (maximum) in 1996 and averaged £2,069.4 million during the period under review. The pre-tax profit had been positive since 1986, except the period from 1990 to 1992. This is due to extremely poor underwriting performance over these years. On the whole, the underwriting performance of the UK non-life insurance business has been poor. Its pre-tax profit has been mainly achieved from good investment returns from financial markets.

The pre-tax profit of life business ranged from –£491.6 million (minimum) in 1991 to £8,043.7 million (maximum) in 1998 and averaged £2,321.8 million during the period under review. The pre-tax profit has been positive since 1986 except for 1991. Compared to its non-life counterpart, life business has enjoyed a good pre-tax profit over the period. The fact that the pre-tax profits of non-life and life business decreased after reaching a peak in the second half of the 1990s was the result of a decline in the investment performance. Therefore, insurance companies should improve their underwriting performance in order to maintain good pre-tax profits.

Figure 2.7: Pre-tax profit of the UK insurance industry (1986-1999)



2.4.3 Balance Sheet

In general, there are three main components in the balance sheet of an insurance company. These components include assets, liabilities and shareholders' funds. Because shareholders' funds have been discussed previously and the accounts of the component of liabilities of non-life and life business are extremely different, this section will only focus on the asset allocation in the UK insurance industry.

Before the discussion of asset allocation, it should be noted that there are at least two differences between non-life and life business, affecting asset distribution. First, non-life business is more risky than life business because the timing and amount of claims are unknown at the inception of a non-life policy, whereas only the timing of claims is unknown at the inception of a life policy. Second, the liabilities of non-life insurance companies are generally short-term, whereas those of life insurance companies are relatively long-term. With a view to avoiding liquidity risk and interest rate risk, non-life insurance companies tend to invest most of their funds in short-term assets, such as cash, short-term deposits and government or investment-grade corporate bonds with a short maturity. Nevertheless, some liability-related policies that are offered by non-life insurance companies have long run-off periods. It usually takes several years, even a decade or two, to know the final claim payments of these policies. Therefore, non-life insurance companies have to hold some assets with long-term maturities against these claims. Moreover, with a view to diversifying their investment holdings, enhancing rates of return and hedging inflation, non-life insurance companies also invest considerable funds in property and equities. As might be expected, life insurance companies tend to invest most of their funds in long-term assets in order to maximise return.

Table 2.5 reports an overall average allocation of assets between categories for the UK insurance industry during the period 1986 through 1999. Tables 2.6 and 2.7 show the proportion of individual asset category to total assets of the UK non-life and life insurance industry over the above-mentioned period respectively.

Table 2.5: Average asset allocation of the UK insurance industry (1986-1999)

Asset category	Non-life	Life
Property	1.8%	6.9%
Cash	8.4%	2.5%
Bonds	24.4%	21.2%
Equities & other shares	12.5%	33.3%
Affiliates	12.9%	1.5%
Insurance debts	10.7%	0.4%
Other assets	4.8%	2.9%
Prepayments & accrued income	2.8%	0.3%
Reinsurers share of technical provisions	21.9%	0.0%
Assets held to cover linked liabilities	0.0%	31.1%

Table 2.6: The proportion of individual asset category to total assets of the UK non-life insurance industry (1986-1999)

Asset category	1986	1987	1988	1989	1990
Property	3.2%	3.4%	3.8%	4.0%	3.7%
Cash	7.6%	8.4%	9.8%	9.3%	9.5%
Bonds	23.5%	24.6%	23.4%	20.8%	19.8%
Equities & other shares	16.9%	16.2%	15.8%	17.4%	14.1%
Affiliates	16.6%	14.4%	14.9%	15.1%	13.0%
Insurance debts	11.1%	10.6%	10.3%	9.8%	11.3%
Other assets	3.9%	4.6%	4.4%	4.8%	5.8%
Prepayments & accrued income	2.1%	2.4%	2.5%	2.5%	2.7%
Reinsurers share of technical provisions	15.1%	15.4%	15.1%	16.3%	20.1%

Table 2.6: The proportion of individual asset category to total assets of the UK non-life insurance industry (1986-1999) (continued)

Asset category	1991	1992	1993	1994	1995
Property	2.9%	2.0%	1.8%	1.6%	1.3%
Cash	9.5%	9.5%	8.9%	10.0%	8.6%
Bonds	20.8%	22.3%	25.3%	25.8%	26.5%
Equities & other shares	12.5%	10.4%	12.1%	12.3%	13.1%
Affiliates	13.6%	13.3%	14.2%	11.7%	13.1%
Insurance debts	11.2%	10.7%	9.6%	9.8%	11.0%
Other assets	5.5%	5.4%	4.7%	4.8%	5.3%
Prepayments & accrued income	2.8%	2.5%	2.3%	2.3%	3.3%
Reinsurers share of technical provisions	21.2%	23.9%	21.1%	21.7%	17.8%

Table 2.6: The proportion of individual asset category to total assets of the UK non-life insurance industry (1986-1999) (continued)

Asset category	1996	1997	1998	1999
Property	1.0%	0.9%	0.6%	0.6%
Cash	8.3%	7.7%	7.1%	6.3%
Bonds	23.0%	26.1%	26.4%	26.2%
Equities & other shares	10.3%	11.6%	11.4%	11.5%
Affiliates	10.8%	11.1%	13.5%	11.5%
Insurance debts	12.7%	10.2%	9.9%	10.9%
Other assets	4.7%	4.3%	4.1%	4.8%
Prepayments & accrued income	2.7%	2.9%	3.0%	3.2%
Reinsurers share of technical provisions	26.5%	25.2%	24.0%	25.0%

Table 2.7: The proportion of individual asset category to total assets of the UK life insurance industry (1986-1999)

Asset category	1986	1987	1988	1989	1990
Property	10.9%	12.3%	13.6%	12.6%	12.1%
Cash	1.7%	2.2%	2.5%	2.5%	3.9%
Bonds	21.8%	21.8%	20.6%	17.8%	18.9%
Equities & other shares	33.6%	30.9%	31.1%	34.1%	31.7%
Affiliates	1.5%	1.3%	1.5%	1.6%	1.7%
Insurance debts	0.5%	0.5%	0.6%	0.5%	0.6%
Other assets	5.1%	5.5%	5.5%	5.1%	5.8%
Prepayments & accrued income	0.0%	0.0%	0.0%	0.0%	0.0%
Assets held to cover linked liabilities	24.9%	25.5%	24.6%	25.8%	25.3%

Table 2.7: The proportion of individual asset category to total assets of the UK life insurance industry (1986-1999) (continued)

Asset category	1991	1992	1993	1994	1995
Property	9.5%	7.5%	6.3%	7.1%	5.9%
Cash	3.3%	3.2%	2.2%	2.0%	2.5%
Bonds	20.2%	22.9%	23.6%	22.3%	21.9%
Equities & other shares	33.4%	33.1%	34.0%	33.8%	34.1%
Affiliates	1.8%	1.7%	1.5%	1.6%	1.8%
Insurance debts	0.5%	0.4%	0.3%	0.3%	0.3%
Other assets	5.2%	4.5%	3.5%	3.3%	2.3%
Prepayments & accrued income	0.0%	0.0%	0.0%	0.0%	0.7%
Assets held to cover linked liabilities	26.1%	26.7%	28.6%	29.6%	30.5%

Table 2.7: The proportion of individual asset category to total assets of the UK life insurance industry (1986-1999) (continued)

Asset category	1996	1997	1998	1999
Property	5.4%	5.0%	4.7%	4.4%
Cash	2.7%	2.8%	2.6%	1.9%
Bonds	21.4%	21.0%	22.2%	19.3%
Equities & other shares	34.6%	34.9%	31.9%	32.6%
Affiliates	1.6%	1.3%	1.3%	1.3%
Insurance debts	0.3%	0.3%	0.3%	0.2%
Other assets	1.8%	1.6%	1.5%	1.2%
Prepayments & accrued income	0.6%	0.6%	0.6%	0.5%
Assets held to cover linked liabilities	31.6%	32.5%	34.9%	38.6%

In the non-life insurance industry, the category of "bonds" was the dominant asset class. The percentage in bonds ranged from 19.8 per cent (minimum) in 1990 to 26.5 per cent (maximum) in 1995 and averaged 24.4 per cent during the period under review. The non-life insurance industry as a whole had invested at least 20 per cent of its funds in bonds over the years, except in 1990.

Table 2.5 reports that "reinsurers' share of technical provisions" is the second largest asset category of the non-life insurance industry. The percentage of reinsurers' share of technical provisions ranged from 15.1 per cent (minimum) in 1986 to 26.5 per cent (maximum) in 1996 and averaged 21.9 per cent during the period under review. There had been an overall upward trend of reinsurers' share of technical provisions over the years, reflecting the fact that non-life insurance companies had increasingly relied on reinsurance.

The category of "affiliate investments" is the third largest asset category of the non-life insurance industry. The percentage of affiliate investments ranged from 10.8 per cent (minimum) in 1996 to 16.6 per cent (maximum) in 1986 and averaged 12.9 per cent during the period under review. There had been a downward trend of affiliate investments over the years, reflecting the fact that the non-life insurance companies had invested fewer funds in their dependants than before.

The category of "equities & other shares" is the fourth largest asset category in investment holdings of the non-life insurance industry. The percentage of equities & other shares ranged from 10.3 per cent (minimum) in 1996 to 17.4 per cent (maximum) in 1989 and averaged 12.5 per cent during the period under review. The underlying trend of non-life investments in equities and other shares was downward during the period under review.

The distribution of investments in the life insurance industry was different from that of its non-life counterpart. Table 2.5 also reports an overall average allocation of assets between categories for the life insurance industry during the period 1986 through 1999. Compared to non-life, there are at least four major differences between the two.

1. The category of "equities & other shares" was the dominant asset class for the life insurance industry, whereas that of "bonds" was the main asset category for non-life.

2. The non-life insurance industry invested a greater proportion of their funds in liquid assets such as cash instead of illiquid assets such as property, whereas the life insurance industry invested relatively more funds in the latter.

3. A high proportion of the funds of life insurance companies had been invested in assets held to cover linked liabilities that are not part of non-life insurance companies' business.

4. On average "reinsurers' share of technical provision" accounted for 21.9 per cent of the assets held by non-life insurance companies, whereas it only accounted for less than 0.001 per cent of the assets held by life insurance companies.

Table 2.5 shows that the categories of "equities & other shares", "assets held to cover linked liabilities", and "bonds" had obviously been the three main asset classes for the life insurance industry. The analysis presented in Table 2.7 shows that the percentage of "equities & other shares" ranged from 30.9 per cent (minimum) in 1987 to 34.9 per cent (maximum) in 1997 and averaged 33.3 per cent during the period under review. The life insurance industry as a whole had invested one third of its funds in "equities & other shares" over these years. Compared with their US counterparts, UK life insurance companies invest a great proportion of their funds in equities.

The percentage of assets held to cover linked liabilities ranged from 24.6 per cent (minimum) in 1988 to 38.6 per cent (maximum) in 1999 and averaged 31.1 per cent during the period under review. The category of assets held to cover linked liabilities has gradually become the dominant asset class in the life insurance industry because of soaring demand for unit-linked insurance products.

The percentage of bonds ranged from 17.8 per cent (minimum) in 1989 to 23.6 per cent (maximum) in 1993 and averaged 21.2 per cent during the period under review. The life insurance industry has invested about one fifth of its funds in bonds over these years.

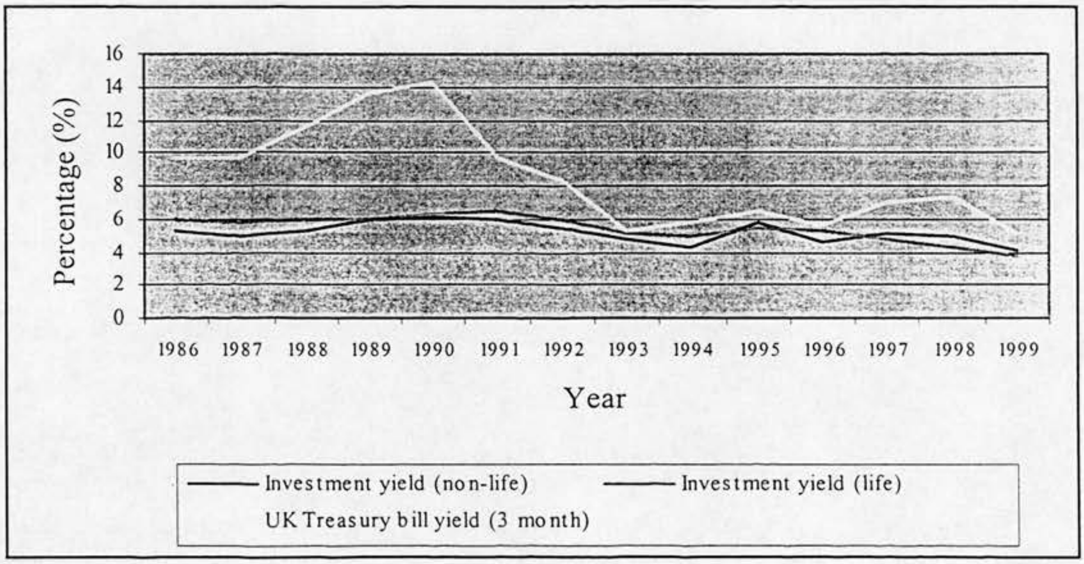
2.4.4 Performance Measures

1. Investment yield[15]

Investment yield is an indicator for measuring profitability and the quality of investment portfolio held by an insurance company. The investment yield of non-life business ranged from 4.1 per cent (minimum) in 1999 to 6.1 per cent (maximum) in 1990 and averaged 5.2 per cent during the period under review, whereas that of life business ranged from 3.8 per cent (minimum) in 1999 to 6.5 per cent (maximum) in 1991 and averaged 5.4 per cent. This measure is also the NAIC Property/Casualty IRIS Ratio 6 (Investment yield) and its usual values range between 4.5 per cent and 10 per cent (NAIC, 2001a). Based on this criterion, the investment yield of the non-life business was outside the safe zone in 1994 and 1999, whereas that of the life business in 1998 and 1999.

Figure 2.8 shows that the insurance industry enjoyed a relatively high investment yield at the beginning of the 1990s. At that time, however, the non-life industry was suffering from very poor underwriting performance. Although the industry's pre-tax profit was still negative (Figure 2.7), the good investment results did offset the bad underwriting results. Enz and Karl (2001) argue that underwriting and investment results are negatively correlated. The rationale behind this negative relationship is that good investment performance usually results in the increase in capital funds, which then leads insurance companies to enter price competition, especially as insurance companies strive for market share. Figure 2.8 also shows that the investment yields of both non-life and life business moved in line with the UK Treasury bill yield. This is possibly because both non-life and life companies invested a significant of their funds in bonds.

Figure 2.8: The UK non-life and life investment yields and the UK Treasury bill yield (1986-1999)



2. Percentage change in shareholders' funds[16]

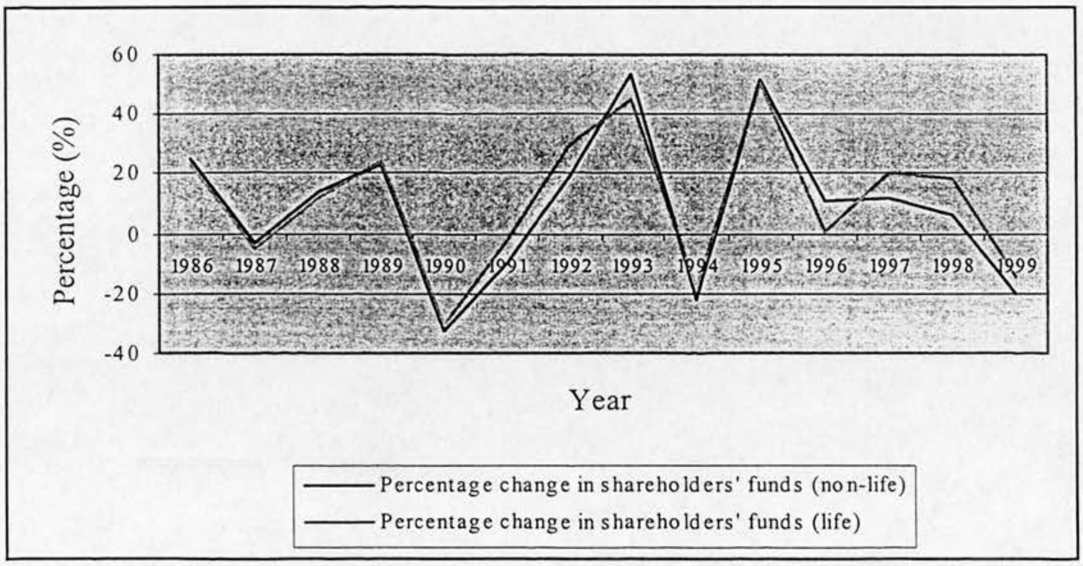
Percentage change in shareholders' funds is usually used to measure the financial condition of an insurance company. The percentage change in shareholders' funds of non-life business ranged from –32.5 per cent (minimum) in 1990 to 53.1 per cent (maximum) in 1993 and averaged 9.0 per cent during the period under review,

---

[15] Investment yield is defined as {(Net investment income)$_t$ / [0.5*((Adjusted total assets)$_{t-1}$ + (Adjusted total assets)$_t$)]}*100%.

whereas that of life business ranged from –30.7 per cent (minimum) in 1990 to 50.1 per cent (maximum) in 1995 and averaged 11.0 per cent. This measure is similar to the NAIC Property/Casualty IRIS Ratio 7 (Change in policyholders' surplus) and the NAIC Life/Health IRIS Ratio 2 (Gross change in capital surplus). The usual ranges of both Ratios are between –10 per cent and 50 per cent (NAIC, 2001a; 2001b). Based on this criterion, the percentage change in shareholders' funds of the non-life business was outside the safe zone in 1990, 1991, 1993, 1994, 1995 and 1999, whereas that of life business in 1990, 1994, 1995 and 1999. Figure 2.9 shows that the measures of both non-life and life business were very volatile during this period. As stated previously, shareholders' funds of the two businesses had moved in a similar way. Therefore, it is hardly surprising that the percentage change in shareholders' funds has moved in the same way as well.

Figure 2.9: Percentage change in shareholders' funds of the UK insurance industry (1986-1999)



3. Return on shareholders' funds[17]

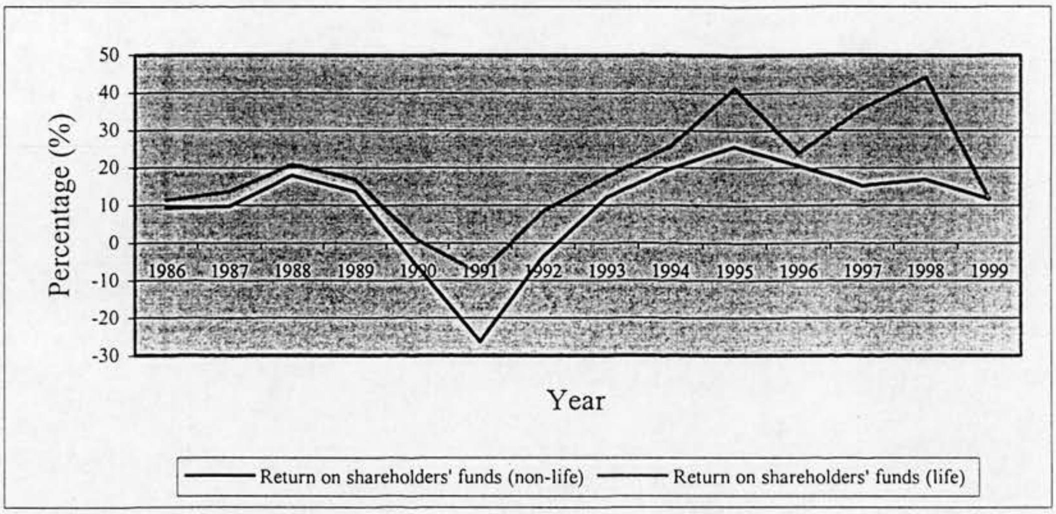
Return on shareholders' funds is similar to return on equity in other industries and is to measure the overall performance of an insurance company. The return on

[16] Percentage in shareholders' funds is defined as {[(Shareholders' funds)$_t$ (Shareholders' funds)$_{t-1}$] / (Shareholders' funds)$_{t-1}$}*100%.

[17] Return on shareholders' funds is defined as {(Pre-tax profit)$_t$/ [0.5*((Shareholders' funds)$_{t-1}$ + (Shareholders' funds)$_t$)]}*100%.

shareholders' funds of non-life business ranged from –26.3 per cent (minimum) in 1991 to 25.8 per cent (maximum) in 1995 and averaged 9.3 per cent during the period under review, whereas that of life business ranged from –8.1 per cent (minimum) in 1991 to 44.1 per cent (maximum) in 1998 and averaged 18.9 per cent. Figure 2.10 shows that the return on shareholders' funds of the two businesses had been positive since 1986, except at the start of the 1990s. Besides, it is noted that life business has consistently outperformed non-life business in terms of return on shareholders' funds over the entire period.

Figure 2.10: Return on shareholders' funds of the UK insurance industry (1986-1999)



2.5 Risks Faced by Insurance Companies

Insurance companies are risk intermediaries and as a result face not only general business risks[18] that are common to other ordinary businesses but those risks which are specific to insurance, such as underwriting risk and reserving risk. The risks faced by insurance companies can be divided into several categories in a wide range of ways. Tables 2.8 and 2.9 summarise some common classifications and classifications in terms of DFA application respectively.

Table 2.8: Risks faced by insurance companies (Common classification)

Professional body/Researcher(s)	Risks faced by insurance companies
Society of Actuaries	1. Asset risk 2. Insurance risk 3. Interest rate risk 4. Miscellaneous risk
Australian Prudential Regulation Authority (APRA, 2000)	1. Insurance risk 2. Investment risk 3. Concentration risk
Ryan et al. (2001)	1. Underwriting risk • Market • Premiums • Claims • Expenses • Social • Reinsurance • Legal/Legislative • Other economic • Currency • Political 2. Asset risk • Assets • Premium reserves • Financing risk • Other economic • Currency • Political 3. Other risk • Operational • Policyholders' reasonable expectations • Dependency • Group structure

The most commonly seen classification of risks by the Society of Actuaries is discussed in more detail as follows. Nevertheless, the discussion here will not be only confined to life insurance.

1. Asset risk

Asset risk reflects the riskiness of the asset portfolio of an insurance company. It is the risk of default for debt assets and decrease in market value of equity assets. The debt assets, such as bonds, held by an insurance company may default. The market value of an insurance company's equity assets may decrease.

2. Insurance risk

---

[18] The general business risks include political risk, operational risk, legal risk and default risk, etc.

Insurance risk, also known as underwriting risk, reflects the uncertainty of future changes in mortality, morbidity, frequency and severity of losses and claims. These adverse changes do happen from time to time. For instance, Sovereign Marine & General Insurance Company's underwriting results worsened during the period of 1988 to 1990 mainly because of an dramatic increase in asbestosis claims. The reserves originally set up were clearly insufficient to pay for the claims and have been strengthened after an actuarial review was carried out (KPMG, 1999). This example shows that inappropriate pricing, which subsequently results in inadequate reserves, could cause financial trouble to an insurance company.

3. Interest rate risk

Interest rate risk is the risk of losses because of changes in interest rate levels. This risk is also referred to as asset-liability mismatching risk because it mainly results from mismatch of the durations of an insurance company's asset and liability portfolios. If the mismatch is huge and interest rates move unfavourably, the insurance company may suffer financial difficulty. For insurance companies with longer duration of assets than that of liabilities, rising interest rates typically will erode the value of surplus.

4. Miscellaneous risk

The category of miscellaneous risk includes all the risks other than the three kinds of risks mentioned above. Miscellaneous risk includes the risk of malfeasance of insurance agents and staffs, and the risk of the change and interpretation of related law and regulations.

Table 2.9: Risks faced by insurance companies
(Classification in terms of dynamic financial analysis application)

Professional body/ Researcher	Risks faced by insurance companies
Faculty and Institute of Actuaries (1996)	1. Concentrations of assets in particular risk areas 2. Derivatives 3. Assets containing unusual provisions which may be susceptible to particular risks 4. Sources of new business which have unusual characteristics 5. Impending major claims or litigation that might affect the company 6. Operational exposure to accidents, terrorism,

	or malicious damage 7. Unusual contracts or relationships which may have financial implications 8. Risks created by deficient product literature or policy documentation 9. Loss of a distribution channel 10. The effect in different scenarios of options and guarantees in the insurance liabilities. In addition, the Faculty and Institute of Actuaries also specify four assumptions that are recommended to be tested and eight assumptions that may be of considerable importance in some insurers. These assumptions will be reported in the next section of the thesis.
Society of Actuaries (1996)	1. Operational risk: • Mortality risk • Morbidity risk • Persistency risk • Expense risk • Investment risk • Liquidity risk • Risk of mismanagement 2. Environment risk: • General economy • Efficiency of economic markets • Legal environment • Competitive forces • Society's perception of insurance • Governmental actions • Accounting actions • Changes in demographic structure • Technological changes • Public health
Casualty Actuarial Society (2000)	1. Asset risk 2. Obligation risk 3. Interest risk 4. Mismanagement risks
Canadian Institute of Actuaries (1998)	Risk categories for life insurance companies: • Mortality • Morbidity • Persistency • Cash flow mismatch • Deterioration of asset values • New business • Expense • Reinsurance • Government and political action • Off balance sheet Risk categories for property-casualty insurance companies: • Frequency and severity • Pricing • Misestimation of policy liabilities

	• Inflation • Interest rate • Premium volume • Expense • Reinsurance • Deterioration of asset values • Government and political action • Off balance sheet
Feldblum (1992)	1. Underwriting risk • Catastrophes • Underwriting cycles • Regulatory action • Parameter risk • Process risk 2. Reserving risk • Unforeseen liabilities • External changes • Internal changes • Inappropriate methods 3. Asset risk • Default risk • Loss of principal • Asset-liability matching 4. Other risks • Reinsurance risk • Credit risk • Management risk
D'Arcy et al. (1997)	1. Balance sheet risk • Asset risk • Liability risk 2. Operating risk • Underwriting risk • Investment risk
Walling et al. (1999)	1. Pricing 2. Loss reserve development 3. Catastrophe 4. Investment

The actuary needs to investigate whether the company is exposed to the risks reported in Table 2.9 while conducting a DFA analysis. However, it should be noted that different companies have different portfolios and accordingly face different categories and magnitude of risk exposures.

Take the classification by D'Arcy et al. (1997) as an example. They divide the risks faced by an insurance company into two main categories, balance sheet risk and operating risk. Balance sheet risk includes asset risk and liability risk. Asset risk is the risk of the changes in asset values. Liability risk, also known as reserving risk, is the risk of the inadequacy of loss reserves. Operating risk includes underwriting risk and investment risk. Underwriting risk, also known as pricing risk, is the risk of the inadequacy of premiums. This risk is related to policies that the insurance company will write or renew in the future. Investment risk involves the uncertainty of the investment incomes, including capital gains and dividends, and inevitably has a very strong connection with general economic conditions.

In addition, it is worth noting that under the FSA's new framework of risk-based approach to supervision, the Integrated Prudential Sourcebook (Financial Services Authority, 2001) classifies risks into six categories: credit risk, market risk, operational risk, insurance risk, group risk, and liquidity risk. The rules regarding the first five risks are described in detail in the Integrated Prudential Sourcebook, whereas those regarding liquidity risk in the FSA's Consultation Paper 128: Liquidity Risk in the Integrated Prudential Sourcebook (Financial Services Authority, 2002).

2.6 Current Practices of Dynamic Financial Analysis in the UK, the USA and Canada

There has been a recent trend among actuarial professional bodies in developed countries towards providing guidelines or standard of practice to help Appointed Actuaries evaluate the financial condition of their individual companies using DFA or its variants. It is anticipated that the insurance regulatory authorities in other countries will follow the trend and require insurance companies to conduct DFA in the future. The purpose of this section is to review the current practices of DFA in the UK, the USA and Canada.

2.6.1 UK

In March 1996, the Life Board of the Faculty and Institute of Actuaries introduced Guidance Note 2 (GN2) on Financial Condition Report (FCR) as Recommended

Practice for Appointed Actuaries responsible for long-term insurance business. In the Section three of GN2, how Dynamic Solvency Testing (DST) can be used to obtain the company's important information required by the report is discussed[19]. DST is conducted using scenario testing and involves projecting an insurance company's solvency position into the future under different assumptions in order to assess its financial strength and identify the main risk factors affecting the company. The main issues arising when DST is conducted can be summarised as follows:

1. Assumptions

GN2 does not specify any assumptions that must be tested. As a whole, they are at the Appointed Actuary's discretion. However, GN2 classifies the assumptions into two categories.

a. Assumptions recommended to be tested

GN2 specifies four assumptions recommended to be tested, unless there are particular reasons. The assumptions include future investment conditions, levels of new business, expenses and persistency.

b. Other assumptions

GN2 also specifies eight assumptions that may be of great importance to some insurers. The assumptions include allocation of profits, mortality and morbidity, taxation, exercising of options by policyholders, exercising of options by the company, effects of assets-defaults, unit pricing bases and default risk of the company's reinsurer.

2. Projection period

---

[19] See Faculty and Institute of Actuaries (1996). In addition, it should be noted that GN2 is recommended practice only for Appointed Actuaries responsible for long-term insurance business. Therefore, it is not statutory practice for life insurance companies, let alone general insurance companies.

GN2 suggests that projection period of five years in DST is sufficient in most cases. However, a longer projection period should be used if the company face some risks whose effects only realise over a longer period.

3. Financial condition report

As stated previously, DST is conducted to obtain the information required in the company's financial condition report. According to GN2, the financial condition report mainly include the purpose of the report, comments on the implications of DST, the development and business of the company and the environment where the company is expected to operate, etc.

2.6.2 USA

1. Life and health insurance

In 1996, the Society of Actuaries published "Dynamic Financial Condition Analysis Handbook" designed as a resource to help actuaries evaluate the financial condition of life and health insurance companies. However, it should be noted that this handbook has not yet been developed as a standard of practice (Society of Actuaries, 1996).

In this handbook, the Society of Actuaries specifies the steps in conducting a dynamic financial condition analysis. They include (Society of Actuaries, 1996):

a. Identify lines of business to be projected
b. Identify risks to be considered
c. Select scenarios to be projected
d. Define projection horizon
e. Determine projection resources
f. Review actuarial standards of practice
g. Identify data requirements
h. Determine the company's minimum capital requirements
i. Establish time and expense budget and timetable

The Society of Actuaries specifically points out that the actuary should identify the necessary scenarios based on the risks the company faces. See Section 2.5 for the risk categories classified in terms of DFA application by the Society of Actuaries.

2. Property-casualty insurance

In 1995, the Casualty Actuarial Society first developed "Dynamic Financial Analysis Handbook" for property and casualty insurance companies. In 2000, the DFA committee of the CAS published "Dynamic Financial Analysis Research Handbook" by combining the original handbook with other newly produced papers on DFA. The purpose of this updated handbook is to provide actuaries with guidance and a list of considerations when conducting DFA. It is noted that the handbook does not prescribe reporting requirements as regards DFA. The format of the relevant report is at the discretion of the actuary conducting DFA. In addition, the handbook does not prescribe a specific projection period, either (Szkoda et al., 1995).

The Casualty Actuarial Society also specifically points out that the selection of a scenario depends on the environment in which the insurance company operates. Moreover, the current and future risks the company faces should also be taken into account. Again, see Section 2.5 for the risk categories classified in terms of DFA application by the Casualty Actuarial Society.

2.6.3 Canada

From January 1 1999, all Appointed Actuaries of insurance companies operating in Canada have been required by the Superintendent of Financial Institutions to prepare financial condition reports based on the Standard of Practice on Dynamic Capital Adequacy Testing issued by the Canadian Institute of Actuaries (1998). This Dynamic Capital Adequacy Testing (DCAT) standard covers not only life insurance companies and fraternal benefits societies, but also property-casualty insurance companies. Before the DCAT standard was issued, the DST standard only covered life insurance companies and fraternal benefits societies.

Generally speaking, DCAT involves testing different scenarios and examines the adverse effect of different scenarios on the insurance company's financial condition and capital adequacy. The main issues arising when DCAT is conducted can be summarised as follows.

1. Scenarios

According to the DCAT standard, scenarios should cover risk factors resulting from both underwriting and investment operations. In addition, scenarios should also take into account the risk factors resulting from not only current insurance business but also future business plan. The DCAT standard classifies the scenarios into two categories.

a. Base scenario

The base scenario is a realistic group of assumptions used to forecast the financial condition of an insurance company and is normally consistent with its business plan over the projection period. If there is any huge inconsistency between base scenario and the business plan, the Appointed Actuary is required to evaluate and justify the inconsistency in the investigation report.

b. Plausible adverse scenarios

The plausible adverse scenarios are the unfavourable scenarios that are likely to occur in the future and that pose great risk to the operation of the company. The DCAT standard lists a number of risk categories in the hope that the Appointed Actuary is alert to the various risk factors that might affect an insurance company. Again, see Section 2.5 for the risk categories classified in terms of DFA application by the Canadian Institute of Actuaries.

It should be noted that the Appointed Actuary should test the base scenario and, at least, three plausible adverse scenarios having the greatest financial impact on the company in accordance with the DCAT standard.

2. Projection period

The DCAT standard suggests that the projection period of five years is appropriate for a life insurance company and that of two years for a property-casualty insurance company.

3. Projection frequency

According to the DCAT standard, the Appointed Actuary should annually make an investigation of the insurance company's financial condition. In the case of a material adverse situation happening, an interim investigation should be conducted immediately.

Overall, most of the risk categories listed by the professional bodies are not concerned with investment conditions. Nonetheless, at present investment risk is one of the most important risks faced by insurance companies. Over the recent years insurers have been adversely affected by the falling price of shares and interest rates. For instance, the UK life insurance industry has been badly hurt because it invests in equities a very significant proportion of the assets it manages and accordingly many life insurers cut bonus payments to policyholders and raise exit penalties. This highlights the importance of testing the financial health of the company under a variety of investment-related scenarios. As indicated in the DCAT standard, the actuary should consider threats to capital adequacy under plausible adverse scenarios that include but are not limited to the risk categories listed above. Therefore, the increased uncertainty over future investment returns requires that a number of plausible adverse scenarios concerning investment conditions be tested such as sharp falls in equity prices.

2.6.4 Empirical Survey of the Practices of Dynamic Financial Analysis/ Dynamic Solvency Testing

Although DFA/DST related techniques have been used in insurance industry for some time, there exist relatively few surveys of current practices of DFA/DST. The results of these surveys which have been undertaken are summarised in Table 2.10.

In order to draft guidance for Appointed Actuaries on FCR, the Dynamic Solvency Testing Working Party of the Faculty and Institute of Actuaries sent a questionnaire to Appointed Actuaries in 153 UK life offices in 1994 investigating the practices of DST in the life insurance industry. In the initial analysis of 29 with-profit offices, the Dynamic Solvency Testing Working Party (1994) found that 34 per cent of the survey respondents reported only carrying out a sensitivity analysis, and 21 per cent scenario testing. Thirty eight per cent of the respondents carried out both a sensitivity analysis and scenario testing, whereas seven per cent did not do any of them. Only 14 per cent of the respondents carried out stochastic projections and inflation, investment returns and investment yields are the variables which are usually treated stochastically. More than two thirds of the respondents indicated that their offices used model points to represent the liability structure, while just over one third reported using most of the in force policies to forecast future liabilities. The most common projection period was five years. The results of DST exercises were normally presented to the Board by the Appointed Actuary.

As mentioned previously, GN2 as Recommend Practice on DST and FCR took effect in March 1996. At the end of 1996, Muir and Sarjant sent a questionnaire to Appointed Actuaries in UK life offices and friendly societies covering the practical issues associated with DST and FCR. Forty-nine replies to this survey were received, including those from 31 offices writing with-profit business[20]. Muir and Sarjant (1997) reported that about 50 per cent of respondents carried out scenario testing as well as sensitivity. They also found that offices writing with-profits business are usually able to conduct more complicated asset modelling than offices which do not

[20] The total number of questionnaires for this survey was not reported in Muir and Sarjant (1997).

write any with-profit business. For instance, 19 per cent of offices writing with-profits business had the capacity to model individual assets, whereas only eight per cent of office which do not write any with-profit business had the same capacity. Regarding liability modelling, roughly a quarter of the respondents used individual policies to project liabilities rather than model points. In addition, according to the survey, the most common projection period was 20 years, but generally only the first five-year results were presented to the Board.

Because the survey by the Dynamic Solvency Testing Working Party (1994) was administered before GN2 took effect, whereas the survey by Muir and Sarjant (1997) was administered less than one year after, these two surveys should have been comparable to some extent. However, it is doubtful whether the findings of the surveys may be validly compared. Most of the questions asked in the questionnaire by the Dynamic Solvency Testing Working Party are different from those by Muir and Sarjant. Very few of the questions in these two surveys are similar. Even if they are, the questions in the survey of Muir and Sarjant are generally more specific and detailed than those in the survey of the Dynamic Solvency Testing Working Party. Moreover, the findings of the Dynamic Solvency Testing Working Party are solely derived from the analysis of with-profit offices while Muir and Sarjant included both life offices and friendly societies in their survey population, in spite of whether they wrote with-profit business or not. In general, offices writing with-profit business are likely to have more complicated techniques of solvency testing, asset and liability modelling than offices which do not write any with-profit business. Further, there was no test for non-response bias conducted for these two surveys. Therefore, it is unknown that to which extent the results of these two surveys were affected by this problem.

Oakden, Friedland and Périgny (2001) invited 36 Canadian property-casualty insurance and reinsurance companies to participate in a study of Appointed Actuaries' approach to DCAT analysis and reporting. Twenty-two companies responded the invitation and were interviewed. Oakden, Friedland and Périgny (2001) reported that Appointed Actuaries were significantly involved in determining input for the base scenario. Scenarios considered significant and included in more than one-half of the DCAT reports of the companies surveyed include frequency and severity of loss, understatement of unpaid claim liability, single catastrophic loss, increase in inflation, increase in interest rates, and deterioration in asset values. On average, more than six scenarios were used. In addition, the length of projection period of DCAT was roughly in line with that of business plan. The DCAT projection period of more than 90 per cent of the companies was less than two years, while the projection period of business plan of more than 90 per cent of the companies was less than three years.

Table 2.10: Empirical surveys of practices of Dynamic Financial Analysis

Professional body/ Researcher(s)	Methodology	Major findings
Dynamic Solvency Testing Working Party, the Faculty and Institute of Actuaries (1994)	Postal survey: Appointed Actuaries in 153 UK life offices	The following findings are based on the results of the initial analysis of 29 with-profit offices: • 72% of respondents carried out sensitivity analysis; 59% scenario testing; 38% both; 7% neither. • 14% of respondents carried out stochastic projections; inflation, investment returns, investment yields are usually treated stochastically. • 69% used model points to model liabilities; 35% used the whole policy file. • The most common projection period was five years. • Results of DST exercises were normally presented to the Board by the Appointed Actuary.
Muir and Sarjant (1997)	Postal survey: Appointed Actuaries in UK life offices and friendly societies	• Approximately 50% of respondents carried out scenario testing as well as sensitivity testing. • 19% of offices writing with-profit business had the capability to model individual assets; 8% of offices which do not writing with-profit business had the same capacity. • Only 26% used individual policy to project liabilities rather than model points. • The most common projection period was 20 years, but generally only the first 5-year results were presented to the Board.
Oakden, Friedland and Périgny (2001)	Interviews: Appointed Actuaries in 22 Canadian property-casualty insurance and reinsurance companies	• Scenarios considered significant and included in more than one-half of the DCAT reports of the companies surveyed include frequency and severity, understatement of unpaid claim liability, single catastrophic loss, increase in inflation, increase in interest rate, and deterioration in asset values. • On average, more than 6 scenarios were used in the companies surveyed. • DCAT projection period: 50% (1 year); 41% (2 years); 9% (3 years). • Business plan projection period: 37% (1 year); 27% (2 years); 27% (3 years); 9% (5 years).

2.7 Summary and Conclusions

In respect to insurance regulations, the FSA currently adopts a risk-based approach to supervision of insurance companies under the FSMA. This approach mainly follows the Basel Accord and aims to achieve four regulatory objectives. The purpose of taking the approach is to focus the FSA's resources on the mitigation of risks to the regulatory objectives, and to have regard to the need to use the FSA's resources in the most efficient and economic way. Under the framework of a risk-based approach, insurance companies should demonstrate that they have adequate financial resources to meet policyholders' claims.

It is worth mentioning that the solvency of insurers is currently adversely affected by the falling equity markets. This is in particular the case to life insurers because they sell a wide range of investment-related products which rely on a rising market to ensure strong investor returns, such as pensions, endowments and with-profit bonds. Life insurance firms are large institutional investors of UK shares. If they sell shares to cut their losses, the price of shares falls further. As a result, John Tiner, the FSA's managing director, wrote to CEOs of UK life insurance firms in January 2003 and invited them to apply to the FSA to waive or modify particular rules which form part of the existing regulatory minimum margin (RMM) calculation in order to break the vicious cycle. This should ensure that life insurers will not have to sell shares when that is not in the best long-term interest of their policyholders.

During the period 1986 through 1999, the UK insurance industry has gone through an era of rapid change. However, some of the trends or characteristics can be summarised as follows:

- *Real growth rates of premium rates and GDP:*

The average real growth rate of GPW of non-life business was slightly smaller than that of GDP. The average real growth rate of GPE of life business was greater and more volatile than that of GPW of non-life business.

- *Shareholders' funds:*

In the late 1980s, the levels of the shareholders' funds of non-life and life business were relatively steady. Since the start of the 1990s, there has been a trend of the increase in the shareholders' funds.

- *Solvency margin ratio and free asset ratio:*

The solvency margin ratio of non-life business had been around 150 per cent in the late 1980s and the early 1990s. In 1991, the solvency margin ratio reached historically low levels and so did underwriting profit and shareholders' funds. Since the second half of 1990s, both solvency margin ratio and shareholders' funds had been increasing and reached record levels. The free asset ratio of life business had a downward trend in the late 1980s and had remained at around 10 per cent since the early 1990s.

- *Underwriting profit and increase (decrease) in fund:*

There were two underwriting cycles during the period under review and underwriting profit of the non-life insurance business reached its trough twice in 1991 and 1998 respectively. The loss magnitude of the first underwriting cycle is greater than that of the second one, indicating that the non-life insurance industry has attached more weight to underwriting performance in order to achieve overall profitability. Before the second half of the 1990s, the funds of life business were relatively stable. After that the funds have been increasing because of good investment performance.

- *Pre-tax profit:*

Both non-life and life insurance businesses reported losses of historically high levels in 1991. Taking the non-life insurance business as an example, its losses were mainly due to poor underwriting results. Nevertheless, when its underwriting results troughed again in 1998, non-life business still had high pre-tax profit, thanks mainly to its good investment performance.

- *Asset allocation:*

"Bonds" and "equities & other shares" were the main asset classes of the non-life and life businesses respectively. During the period under review, on average the non-life insurance industry invested one fourth of its funds in bonds. Compared to its non-life counterpart, the life insurance industry invested more than 30 per cent of its funds in equities and other shares.

- *Percentage change in shareholders' funds:*

The percentage changes in shareholders' funds of both non-life and life business were very volatile, but moved in a similar way. In terms of criterion set by the NAIC, the non-life business was not in the safe zone in 1990, 1991, 1993, 1994, 1995 and 1999, whereas the life business in 1990, 1994, 1995 and 1999.

- *Return on shareholders' funds:*

The return on shareholders' funds for non-life and life business had been positive except in the start of the 1990s. In terms of return on shareholders' funds, the life insurance business has consistently outperformed non-life business.

- *Investment yield:*

The investment yields of both non-life and life business moved in line with interest rates. There had been a downward trend in investment yields since the beginning of the 1990s.

This chapter has also reviewed the current practices of DFA in the UK, USA and Canada. As far as this author can discover, very few surveys of the DFA practices have been conducted. Moreover, for the reasons indicated in the previous section it is doubtful whether the findings of the surveys may be validly compared.

The review of the literature and the practices conducted in this chapter has suggested at least one main area where further empirical research is necessary. This area is mainly concerned with the current practices of DST/DFA/FCR in the UK. First, there is a need for an up-to-date survey of the current practices of DST and FCR in the UK insurance companies and friendly societies carrying on long-term business. The last survey to investigate this question was distributed in 1996 (Muir and Sarjant, 1997). Since this survey was conducted just less than one year after GN2 was formally introduced into the solvency monitoring process, some insurance companies might still be not ready to conduct DST and prepare financial condition report based on GN2. Moreover, the capacity of computers and the training of actuaries are more advanced and better than ever. Presumably the DST and FCR practices of the insurance companies have changed to some extent and the proportion of companies employing relatively complicated techniques is now greater than that indicated in the report by Muir and Sarjant (1997).

Moreover, to the author's knowledge a survey of the practices of DFA and FCR of the UK insurance companies carrying on general business has never been administered before. In order to review the current practices and see whether or not a Guidance Note similar to GN2 is needed for actuaries in the UK general insurance industry, it is essential to carry out a similar survey of the practices, as the Dynamic Solvency Testing Working Party did in 1994 for drafting GN2. Moreover, the survey results of general insurance industry may be used to compare with those of life insurance industry, although some limitations might exist because of the nature of the two industries.

Chapter Three

The Application of Dynamic Financial Analysis in the Insurance Industry

3.1 Introduction

Dynamic Financial Analysis (DFA), by jointly modelling assets and liabilities, provides a means to more closely integrate the management of underwriting and investment operations. Due to its recognition of the interdependence among all facets of the insurance business, DFA has gradually emerged as a tool that actuaries use to evaluate the impact of various business decisions on the company's risk/ reward profile. The purpose of this chapter is to discuss a number of important DFA related issues, including the process of conducting a DFA, the DFA techniques and the driving factor and cascade structure in DFA models.

The remainder of this chapter is organised as follows. Section 3.2 presents the whole process of conducting a DFA. Section 3.3 discusses DFA techniques and their individual advantages and disadvantages. Section 3.4 illustrates how driving factors work in a cascade structure. The final section summarises and concludes this chapter, and one more possible future research area based on the discussion in this chapter is also suggested in the same section.

3.2 The Process of Conducting Dynamic Financial Analysis

The process of conducting a DFA largely depends on its objectives and purposes. As will be discussed in the Section 3.3, DFA techniques can be broadly classified into two categories. These are scenario testing and stochastic simulation. Thus, the process also, inevitably, depends on which techniques used. However, the main steps in conducting a DFA are similar and those using stochastic simulation are outlined as follows:

Step 1: Investigation of the risks faced by the company and the current practices of DFA

The first step in the process of DFA is to investigate the risks faced by the company and the current DFA practices. As indicated in Chapter 2, it would be useful for the actuary to investigate whether the company is exposed to the risks listed in Table 2.9 in the application of a DFA model to a particular insurer. In order to understand the possible risks in great detail, it is deemed advisable to examine the financial statements of the company such as technical account (revenue account), non-technical account (profit and loss account), and balance sheet. By examining these financial statements, the actuary has a better understanding of the risk profile of the company. The examination of financial statements of the UK non-life and life insurance sectors has been conducted in Chapter two.

In addition, the actuary should investigate the current practices of DFA with a view to understanding what level of detail and specific components are included in DFA models by practitioners. Moreover, from this step onwards, the actuary should constantly review relevant guidance notes or standards of practice issued by regulators or actuarial professional bodies in order to comply with the relevant regulations. The investigation of current DFA practices in the UK non-life and life sectors is carried out in Chapters six and seven. As for the relevant guidance notes or standards of practice, they can be found in Chapter two.

Step 2: Identify important economic and firm-specific factors affecting company performance

Before a DFA model can be built, it is essential to determine which factors should be included in the model. The factors to be included are supposed to have financial impact on company performance. However, it should be noted that it is neither possible nor necessary to include all the factors affecting company performance in the model to represent the complicated reality. Therefore, the actuary who is charged with building the model usually only considers the factors that pose material threats to company performance.

The actuary normally uses professional judgement to determine which factors should be included in the model based on his or her understanding of the company's risk exposures. In general, it is sufficient to do so. On some occasions, however, the actuary might not be able to identify all the important factors or to give appropriate weights to the factors identified. Therefore, it is necessary to develop a more scientific means to assist the actuary in finding out these important factors. It is suggested in this thesis that econometric techniques using panel data can serve this purpose. Two empirical analyses conducted for the UK non-life and life insurance sectors are presented in Chapter eight.

Moreover, the factors to be considered should include economic factors as well as firm-specific factors. Previous studies have shown that a wide range of economic and firm-specific factors might have financial impact on company performance. See Chapter four for the literature review on determinants of insurance company performance.

Step 3: Choose one or more performance and risk measures

The third step in the process of DFA is to choose an appropriate performance measure based on the purpose of the analysis. The performance measure chosen serves as an instrument in evaluating the financial impact on company performance under a wide range of scenarios or strategies. Performance measure is also known as objective function, reward measure (Almagro and Sonlin, 1995; Burkett, McIntyre, and Sonlin, 2001) or return measure (Bohra and Weist, 2001). In addition, if the DFA model is used to evaluate strategies an appropriate risk measure should be selected under the framework of classical investment portfolio analysis. For instance, when the DFA model is used to evaluate asset allocation strategies expected surplus is often chosen as the performance measure and the standard deviation of the surplus as the risk measure.

Since insurance operations are complicated and interrelated, however, there could be a number of theoretically and/or practically appropriate measures that can serve the purpose. Therefore, several measures sometimes are simultaneously used in the analysis in order to present the whole picture of the actual situation.

Step 4: Determine projection period

The projection period mainly depends on the characteristics of the risks to which the company is exposed. Generally speaking, the projection period should be long enough to capture the full effects of the risks. Therefore, the projection period of a life office is often longer than that of a general insurer. There are two primary reasons for this. First, the liabilities and assets of a life insurer are relatively long-term compared with those of a non-life company. The effects of the risks of a life office generally take longer to become apparent than those of a non-life firm. Second, the liabilities of a non-life company are relatively uncertain compared to those of a life company because both occurrence time and amount of the claims of a general insurer are unknown at the outset of a contract, whereas the amount of the claims of a life insurer is known. There is no point in projecting cash flows of a non-life company for a very long time period because the spread of variability increases with time and the projection accordingly would become relatively unreliable as the projection period is lengthened.

Step 5: Build a DFA model

The first stage of building a DFA model is normally to choose one or more driving factors from economic factors. Then the stochastic processes of the driving factors are used to simulate likely future economic conditions. Common driving factors including interest rate and inflation rate will be discussed in Section 3.4. It should be noted that the stochastic processes should be calibrated before they can be used to simulate. The aim of calibration is to determine the appropriate values for parameters of stochastic processes. Once the future economic conditions are simulated, the financial market returns are then consistently determined. Other important issues on building a DFA model are discussed throughout this chapter.

Step 6: Project cash flows

Once built, the model projects future cash flows. Thousands of iterations of financial results are generated and output distributions of the results are produced. The higher the number of iterations, the more reliable the distribution of financial results is likely to be. However, it should be noted that the reliability could not be increased further as the simulation runs reach a certain limit number.

Step 7: Sensitivity testing

The aim of sensitivity testing in DFA is to check whether or not the results obtained are the product of a particular set of assumptions or the result of a particular set of random scenarios (Burkett, McIntyre and Sonlin, 2001). The key input factors in DFA have to be tested to scrutinise key assumptions and assess the impact of a change in the assumptions on performance measures.

Step 8: Interpret the results and provide feedback

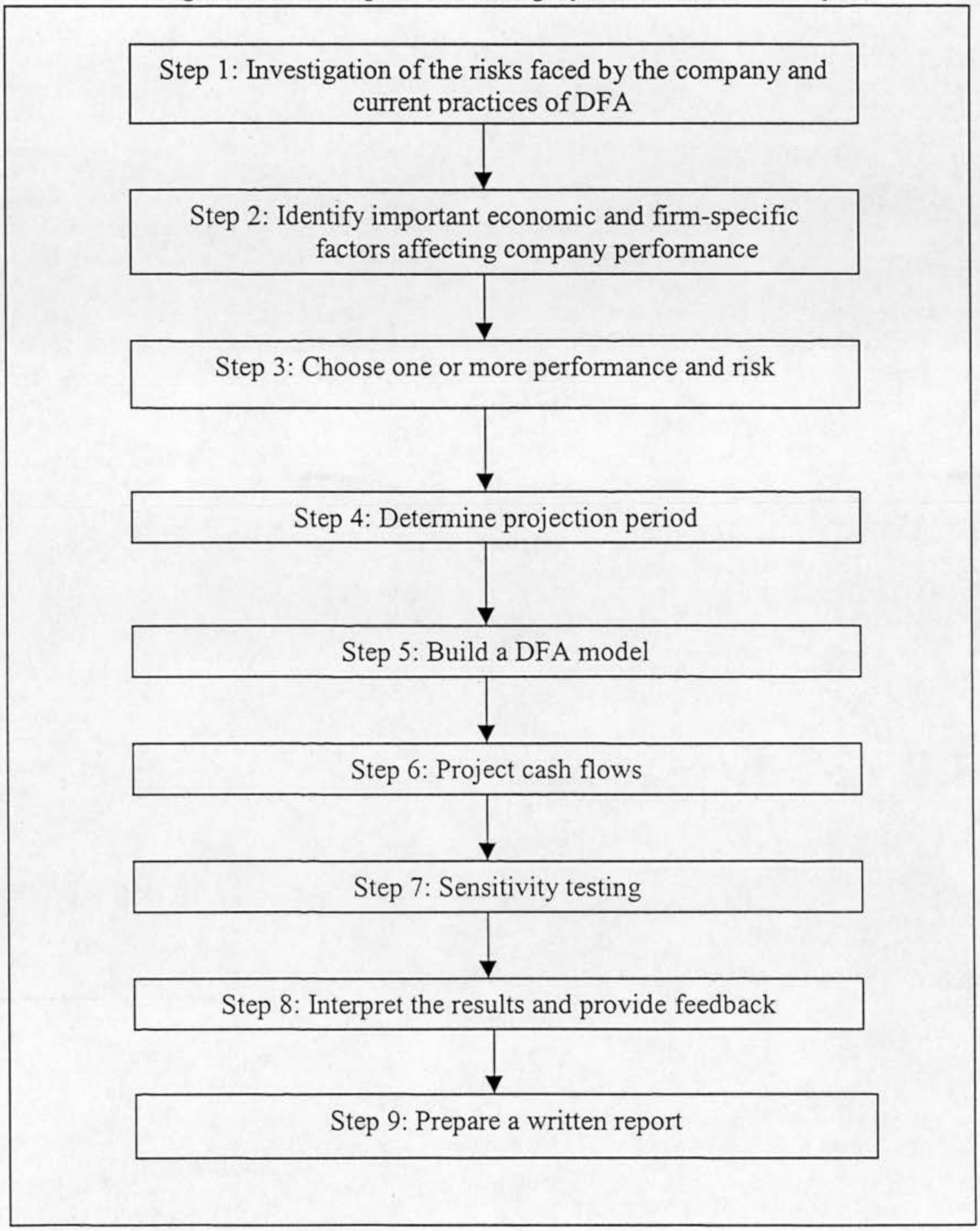
The financial results obtained from the DFA should be carefully discussed and interpreted. If the results under some plausible adverse scenarios are not acceptable, the actuary has to identify the causes and suggest alternative possible corrective measures to be taken.

Step 9: Prepare a written report

The preparation of a written report to senior management is the final step of the DFA. The content of the report depends on the purpose of the analysis. For instance, the report is often referred to as the financial condition report if the purpose of the analysis is to test the solvency of a company under plausible adverse scenarios. The report should normally, at a minimum include the purpose of the analysis, methods and assumptions, scenarios, findings, restrictions to the analysis, recommendations, and so forth.

The above steps in conducting a DFA are summarised in Figure 3.1.

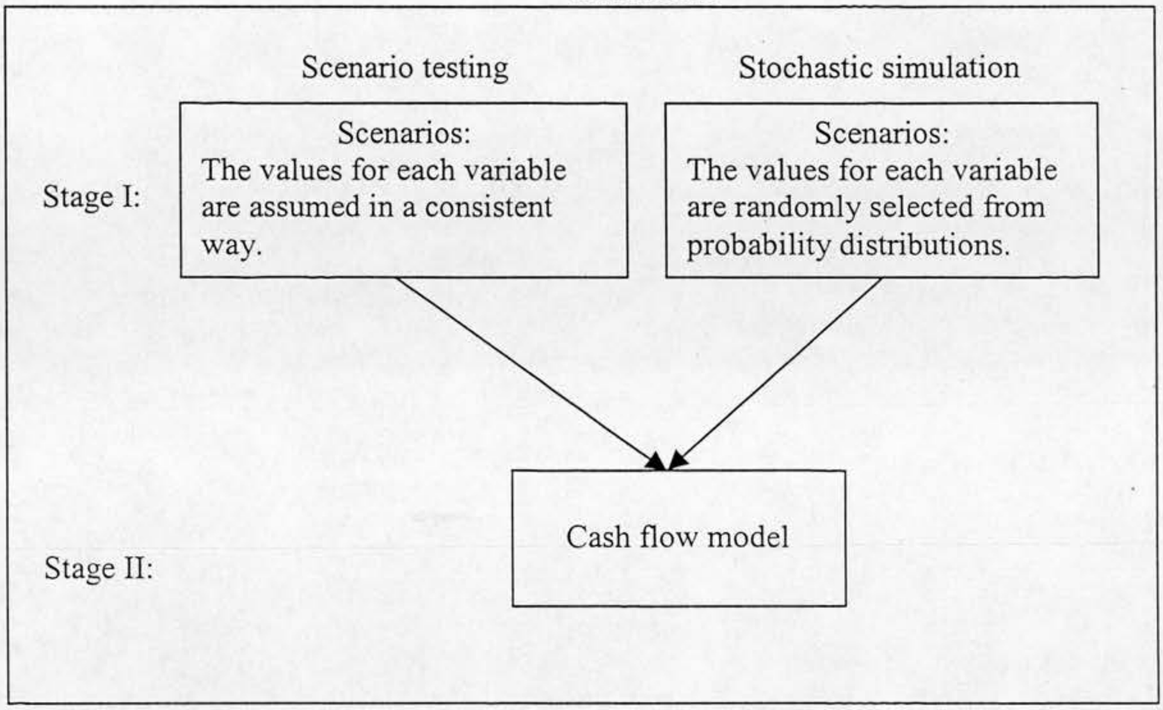
Figure 3.1: The steps in conducting Dynamic Financial Analysis



3.3 Dynamic Financial Analysis Techniques

DFA techniques fall within two broad categories: scenario testing and stochastic simulation. Scenario testing projects financial results under groups of assumptions of variables that are assumed to change in a consistent way. Each group of consistent assumptions of variables is called a scenario. For instance, it is common to assume that high (low) inflation rates accompany high (low) interest rates. However, it should be noted that the assumptions of consistency are not always valid. There could be some periods when consistency has been invalidated. One of the possible reasons for inconsistency is the time lag existing between variables. For example, it takes time for an insurer to adjust its capital shock in response to a rise in the demand for its products. Stochastic simulation models uncertainty by randomly selecting values from probability distributions for each variable. These values for each variable are then used to calculate a large number of resulting scenarios. The main difference between these two techniques is that the former starts with building scenarios in which variables are assumed in a consistent way, whereas the latter usually starts with the assumption of independence between the variables which need to be simulated. In general, the scenarios built for scenario testing are therefore more realistic than most of the resulting scenarios generated stochastically for stochastic simulation. As to the main similarity, all the values for each variable in the scenarios for scenario testing and stochastic simulation are input into a cash flow model to calculate outcomes. Figure 3.2 shows the main difference and similarity between scenario testing and stochastic simulation.

Figure 3.2: The main difference and similarity between scenario testing and stochastic simulation.



These two techniques have their own advantages and disadvantages. For instance, the results of stochastic simulation often show very technical terms, which are sometimes difficult to understand for management, such as the probability of ruin. Moreover, the probability distributions assumed for the variables are sometimes doubtful. Furthermore, as mentioned above, stochastic simulation usually sets an unrealistic assumption that the simulated variables are independent of each other. In fact, there are dependencies between balance sheet elements because they may be affected by common factors. For example, the changes in the value of a given asset may be correlated with those of another asset. Similarly, the experiences of difference insurance products may tend to vary in concert. Also, most of economic and financial variables included in DFA are often correlated to each other. For instance, if inflation rate goes up this is frequently followed by an increase in interest rates. Actuarial analysts have to attempt to model all significant dependencies when conducting a DFA analysis. The correlations between variables should be incorporated into the simulation process. Nonetheless, the analysts must bear in mind that there are two major problems associated with correlation. The first is that correlation is not always the same over the forecast period. The second problem is that known dependency relationships may not be maintained and past causal relationships are sometimes not indicative of future relationships. These problems have to be properly addressed in developing a DFA model. But how do the analysts induce correlation between variables in the simulation algorithms? There are a number of simple methods to achieve this such as the Cholesky Factorisation, the Normal Copulas, and the Cario-Nelson method. Additionally, a number of time-series approaches such as transfer functions can also be employed to impose a covariance structure on a set of variables. These approaches provide methods to generate correlated variables. If analysts fail to include these correlations in stochastic models, the risk or uncertainty of the financial condition of an insurance company would be underestimated[1]. As shown in Figure 3.2, the interrelationships also can be introduced at the second stage of stochastic simulation in order to compensate for the interdependency problem. For instance, it is not necessary to simulate every economic variable in order to get its realised value. Instead, we can use one or more economic variables as the primary driving factors, such as short-term interest rates and inflation rates. The values of these driving factors are simulated and are then used to determine the values of other variables using a cascade structure. This cascade (top-down) structure not only compensates for the above-mentioned drawback, but also makes the variables in question consistent. The next section discusses driving factors and cascade structures.

Stochastic simulation has three advantages. First, a wide range of scenarios can be simulated with the help of the capability of modern computers. By increasing the number of simulation runs, more scenarios can be obtained and simulation results are more stable. Second, stochastic simulation can account for the stochastic nature of insurance operations (D'Arcy et al., 1997). Through a number of stochastic simulations, a general picture of the likely future developments of financial condition of an

[1] Pentikäinen (1988) indicates that the variables should not be assumed to be mutually independent and such an assumption would lead to an underestimation of the risks. Feldblum (1992) also points out that separate consideration of interrelated risks is insufficient and this interdependence of risks carries the most danger for insurance solvency.

insurance company can be obtained. Other advantages of stochastic simulation include the following (Pentikäinen, 1988):

- Confidence areas and the uncertainty in the projections can be shown.
- Explicit statement of the assumptions can be made.
- Easily grasped graphical presentations can be provided.

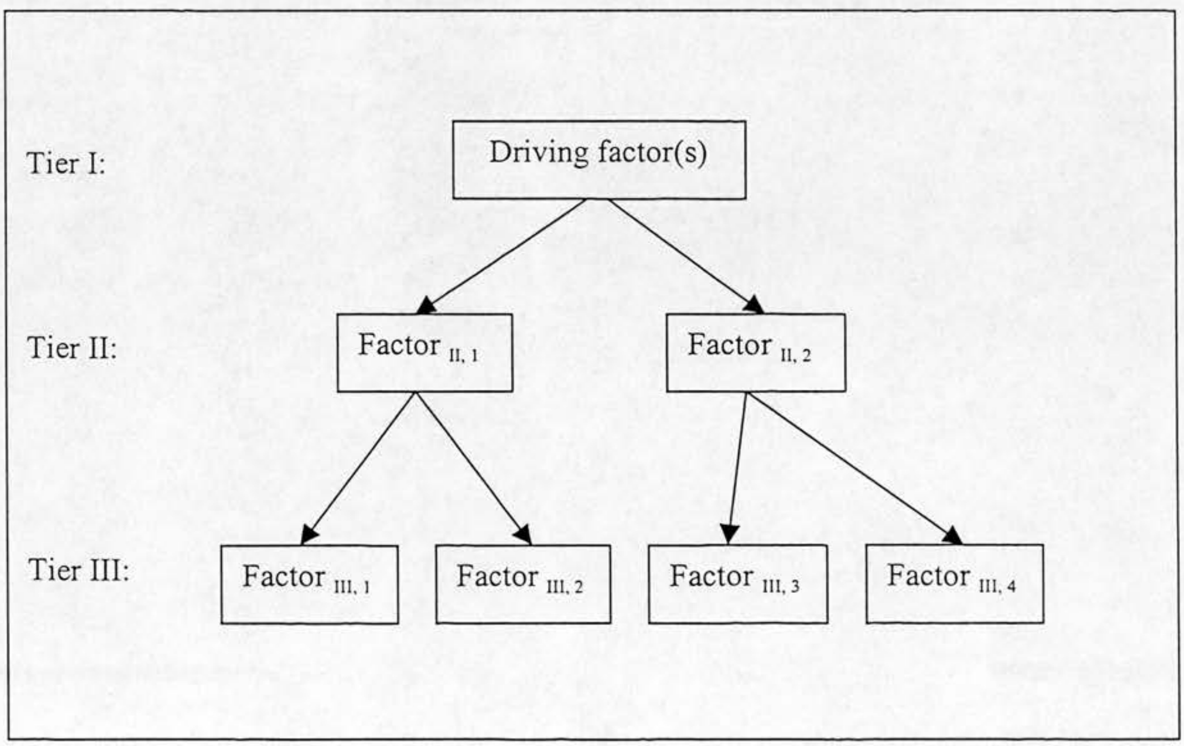
Compared with those for stochastic simulation, the scenarios built for scenario testing are more meaningful, tangible and consistent, and the results are accordingly relatively easy to understand. However, these scenarios for scenario testing are limited to the actuary's preconceived notions about likely future adverse developments of economic and financial conditions, and may not be exhaustive. Nevertheless, it should be noted that the scenarios for scenario testing may be sufficient although they may not be exhaustive. If the actuary has a complete picture of the risk profile of the company and a good understanding of the market environment where the company operates, it is possible to build models which have sufficient scenarios.

Of these two techniques, what approach is better? The short answer is that it depends on the types of questions asked. Each of them is more appropriate in certain situations. For example, scenario testing would be the relatively appropriate approach to answering a question like: "How would the net cash flows of an insurer change under the following conditions?". When analytic solutions become too complex to obtain or there are no closed-form solutions, stochastic approach would be more suitable than scenario testing. For instance, simulations are particularly useful to determine "how much capital would be required in order that there is a 95 per cent probability that the surplus of an insurer will fall below the beginning statutory surplus over the next five years?".

3.4 Driving Factors and Cascade Structure in DFA Models

As mentioned previously, one or more driving factors are usually utilised in DFA especially those using stochastic simulation. In general, cascade structure is also adopted. In the format of cascade structure, factors at the top of the structure influence those below. The influence is usually one-way. That is, factors at the lower tier of the structure cannot influence those at the upper tier of the structure. It should be noted that the cascade structure does not imply causality between factors, but rather captures significant co-movements. Driving factors are the factors at the highest tier of cascade structure. After the driving factors are established, other values of variables can be subsequently and consistently determined. See Figure 3.3 for an example of a typical three-tier cascade structure illustrated diagrammatically, with arrows indicating how different factors at different tiers feed into each other.

Figure 3.3: An illustrated example of a cascade structure



Interest rate and inflation rate are the two most common driving factors. In the DynaMo, a public access DFA model, the interest rate is used as the only driving factor (D'Arcy et al., 1997; 1998), whereas the inflation rate is the only driving factor in the Wilkie investment model (Wilkie, 1986; 1995). Daykin, Pentikäinen and Pesonen (1994) point out that it makes no huge difference which economic factor is taken as the driving factor. As is well known, however, the movements of interest rates have financial impact on the both sides of balance sheet of an insurance company especially on the asset side and inflation is a major factor in determining the liabilities. Therefore, it appears to me that the actuary who is in charge of conducting a DFA may choose interest rate as the driving factor if more emphasis is placed on the asset side, whereas inflation rate may be chosen if more emphasis is placed on the liability side.

It is also noteworthy that the number of driving factors most depends on the purpose of the model. If the model is constructed for forecasting purpose, including more driving factors in the model usually can improve the accuracy of forecasting. For instance, the CAP: Link, developed primarily for asset liability management by Towers Perrin, uses both interest rate and inflation rate as driving factors. The first tier of the cascade structure consists of short and long interest rates, and price inflation (Mulvey and Thorlacius, 1998). If the model is built for testing purposes such as resilience testing, it is sufficient to use only one driving factor, controlling the other relevant indicators by means of assumed interacting correlations (Daykin, Pentikäinen and Pesonen, 1994). The rest of this section will briefly illustrate how the interest rate and inflation rate are used as driving factors in the DynaMo and the Wilkie investment model respectively.

3.4.1 Interest Rate as the Driving Factor in DynaMo

1. Interest rate

In the DynaMo, interest rate is the driving factor and future interest rates are projected using Cox, Ingersoll and Ross model (CIR model)[2]. The CIR model is a one-factor equilibrium model and can be presented as follows:

$$dr_t = a(m - r_t)dt + \sigma\sqrt{r_t}\,dz_t \tag{3.4.1}$$

where r_t is instantaneous short rate at time t; a is the parameter controlling average length of the time of the mean reversion[3] (or the speed of mean reversion); m is the long-run mean level to which the short-term rate reverts; σ is the volatility (standard deviation) of the short-term rate; dz_t is a standard Wiener process (Brownian motion).

A discrete-time form of this model is

$$\Delta r_t = a(m - r_t)\Delta t + \sigma\sqrt{r_t}\,\Delta z_t \tag{3.4.2}$$

The price at time t of a zero-coupon (discount) bond that matures at time T is

$$P(r,t,T) = A(t,T)e^{-B(t,T)r_t} \tag{3.4.3}$$

where

$$B(t,T) = \frac{2\left(e^{r(T-t)} - 1\right)}{(r+a)\left(e^{r(T-t)} - 1\right) + 2r} \tag{3.4.4}$$

[2] Different DFA or investment models using interest rates as the driving factors may use different interest rate models to generate future interest rates. For instance, a variant of the two-factor Brennan-Schwartz approach is used in the CAP: Link to generate future long and short interest rates (Mulvey and Thorlacius, 1998).

[3] Mean reversion is a one of the characteristics of the movements of interest rates. It means that interest rates tend to come back to their long-run mean level. In other words, interest rates usually do not

$$A(t,T)=\left[\frac{2re^{(a+r)(T-t)/2}}{(r+a)\left(e^{r(T-t)}-1\right)+2r}\right]^{\frac{2am}{\sigma^2}} \tag{3.4.5}$$

$$r=\sqrt{a^2+2\sigma^2} \tag{3.4.6}$$

The yield-to-maturity at time t of a zero-coupon (discount) bond that matures at time T is

$$R(r,t,T)=-\frac{1}{T-t}\ln A(t,T)+\frac{1}{T-t}B(t,T)r_t \tag{3.4.7}$$

The future interest rates (90-day T-bill rates) are projected by modelling their incremental movements using (3.4.2), the discrete-time form of the CIR model. Then bond prices are subsequently determined using (3.4.3) to (3.4.7). According to historical interest rate data and professional judgement, the user of the CIR model can adjust the estimates of the parameters to reflect his or her projection of future market conditions. Moreover, the short-term interest rates generated by the CIR model are always greater or equal to zero, which matches the real world (Cox, Ingersoll, and Ross, 1985). However, in the discrete approximation of this model, negative interest rates can occasionally occur.

D'Arcy et al. (1997, 1998) and Walling et al. (1998) offer three reasons for adopting the CIR model to generate future interest rates. First, because property-liability insurance companies generally hold short-term asset and liability portfolios they are less exposed to interest rate risk than banks and life insurance companies, which have to perform more complicated and accurate interest rate models. Second, one of the purposes of constructing this public access DFA model is to let the actuaries, who are usually not

---

continuously go up or go down for a long period of time. It should be noted that mean reversion does not exist in the cases of inflation rates and share prices.

very familiar with interest rate modelling, understand each component of the interest rate model. Obviously, the CIR model serves this purpose. Third, the CIR model balances flexibility, simplicity and intuitive appeal.

2. Inflation rate

After future interest rates are projected using the CIR model discussed above, future inflation rates are generated using the following linear regression formula

$$I_{CPI} = a + br + s\varepsilon \tag{3.4.8}$$

where I_{CPI} denotes general inflation rate; a and b are constants; r is interest rate; s denotes the standard deviation of the residuals (volatility parameter) and ε denotes a random sampling from the standard normal distribution.

For each different line of business, the individual inflation rate is calculated based on the estimate of general inflation rate I_{CPI}.

$$I_{LOB} = a + bI_{CPI} + s\varepsilon \tag{3.4.9}$$

where I_{LOB} is the inflation rate for each line of business.

The rationale of the linear regression of interest rates and general price inflation is the expectation of a positive correlation between them (Walling et al., 1999). The positive relationship between interest and inflation rates can be shown from the following formula of the Fisher Effect.

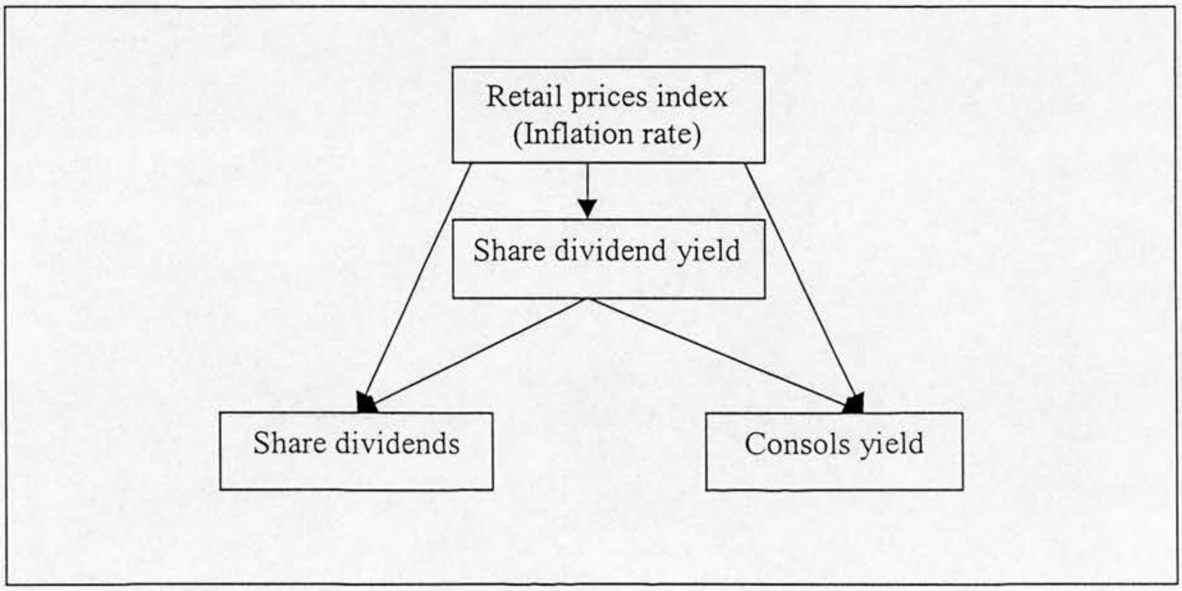
$$i_{nominal} = i_{real} + E(I) \tag{3.4.10}$$

where $i_{nominal}$ and i_{real} denote nominal and real interest rates respectively; $E(I)$ denotes the expectation of inflation.

3.4.2 Inflation Rate as the Driving Factor in the Wilkie Investment Model

The Wilkie investment model was the first comprehensive UK actuarial stochastic asset model and is extensively used in the UK. In this model, a cascade structure is used to interrelate four variables, including retail prices index, share dividend yield, share dividends, and yield on 2.5% Consols[4]. Retail prices index, which can be converted into inflation rate, is the driving factor in this cascade structure shown in Figure 3.4[5].

Figure 3.4: The cascade structure of the Wilkie (1986) investment model



[4] Consols, issued in the UK, are undated fixed-income government securities, which make a fixed periodical payment. Since there is no maturity for consoles, they can be regarded as irredeemable government bonds or perpetual annuities. Wilkie regards the yield on 2.5 per cent Consols as a measure of the general level of fixed interest yields in the market (Wilkie, 1986).

[5] Wilkie updated the Wilkie investment model (Wilkie, 1986) by renewing the data and extending the model to include more variables such as wages index, yields on index-linked stock, short-term interest rates, property yield and income, and currency exchange rates, and so on (Wilkie, 1995). Since these extensions left the structure of the original model virtually unaltered (Huber, 1997) and it has a relatively

1. The inflation process

The inflation process *Q(t)*, which is retail prices index, is as follows.

$$\Delta \ln Q(t) = QMU + QA(\Delta \ln Q(t-1) - QMU) + QSD * QZ(t) \qquad (3.4.11)$$

where Δ is the backward difference, i.e. $\Delta lnQ(t)=lnQ(t)-lnQ(t-1)$; *QMU* is the parameter of the fixed mean; *QA* is the adjustment parameter, which decides the deviation of this year's inflation rate from the mean, by including the deviation of last year's inflation rate from the mean; *QSD* is the standard deviation and *QZ(t)* is a series of unit normal variable, i.e. $QZ(t) \sim iid\ N(0,1)$.

The inflation process can be expressed in terms of inflation rate, *I(t)*, as follows:

$$I(t) = QMU + QA(I(t-1) - QMU) + QSD * QZ(t) \qquad (3.4.12)$$

where $I(t)= ln\ (Q(t)/Q(t-1))$ is the inflation rate over the period of *t-1* through *t*.

The best estimates of each parameter recommended by Wilkie are as follows[6]:

QMU=0.05; *QA*=0.6; *QSD*=0.05

2. The share dividend yield process

---

succinct cascade structure, the discussion here is mainly focused on the original model instead of the extended one.

[6] All of the estimates of the parameters in the Wilkie investment model are the most appropriate ones from an actuary's point of view (Wilkie, 1986). It should be noted that Wilkie (1995) re-evaluates all of the three parameters in the inflation process and that the estimate of parameter *QMU* in Wilkie (1995) is 0.0364, which is extremely different from 0.05 in Wilkie (1986). The choice of parameters, based upon the historical experience and expectations for the future, requires considerable judgement, having regard to the purpose for which the model is to be used (Daykin et al., 1994).

The share dividend yield process $Y(t)$ is based on the above inflation process.

$$\ln Y(t) = YW * \Delta \ln Q(t) + YN(t) \tag{3.4.13}$$

where

$$YN(t) = \ln YMU + YA(YN(t-1) - \ln YMU) + YSD * YZ(t) \tag{3.4.14}$$

where YMU and YA are parameters, YSD is the standard deviation and $YZ(t)$ is standard normal variable .

The best estimates of each parameter recommended by Wilkie are as follows:

YMU=0.04; YA=0.6; YW=1.35; YSD=0.175

3. The share dividends process

The share dividends process $D(t)$ is based on both the inflation process and the share dividend yield process.

$$\begin{aligned}\Delta \ln D(t) = {} & DW * DM(t) + DX * \Delta \ln Q(t) + DMU + DY * YE(t-1) \\ & + DB * DSD * DZ(t-1) + DSD * DZ(t)\end{aligned} \tag{3.4.15}$$

where

$$DM(t) = DD * \Delta \ln Q(t) + (1 - DD)DM(t-1) \tag{3.4.16}$$

Here $DM(t)$ consisting of the current inflation rate and one-year lag value, is a transfer function. $DM(t)$ can be derived as follows:

$$
\begin{aligned}
&DM(t) \\
&= DD * \Delta \ln Q(t) + (1 - DD)DM(t-1) \\
&= DD * \Delta \ln Q(t) + (1 - DD)[DD * \Delta \ln Q(t-1) + (1 - DD)DM(t-2)] \\
&= DD * \Delta \ln Q(t) + DD(1 - DD) * \Delta \ln Q(t-1) + (1 - DD)^2 * DM(t-2) \\
&= DD * \Delta \ln Q(t) + DD(1 - DD) * \Delta \ln Q(t-1) + (1 - DD)^2 * [DD * \Delta \ln Q(t-2) + (1 - DD)DM(t-3) \\
&= DD * \Delta \ln Q(t) + DD(1 - DD) * \Delta \ln Q(t-1) + DD(1 - DD)^2 * \Delta \ln Q(t-2) + (1 - DD)^3 * DM(t-3 \\
&= \dots\dots\dots \\
&= \sum_{i=0}^{\infty} \left[DD * (1 - DD)^i * \Delta \ln Q(t-i) \right]
\end{aligned}
$$

The best estimates of each parameter recommended by Wilkie are as follows:

DW=0.8; DD=0.2; DX=0.2; DMU=0.0; DY= 0.2; DB=0.375, DSD=0.075

4. The Consoles yield process

The Consols yield process $C(t)$ is based on both the inflation process and the share dividend yield process.

$$C(t) = CW * CM(t) + CN(t) \tag{3.4.17}$$

where

$$CM(t) = CD * \Delta \ln Q(t) + (1 - CD)CM(t-1) \tag{3.4.18}$$

Here $CM(t)$ consisting of the current inflation rate and one-year lag value, is also a transfer function.

And

$$
\begin{aligned}
\ln CN(t) &= \ln CMU + CA1 * \ln\left(\frac{CN(t-1)}{CMU}\right) + CA2 * \ln\left(\frac{CN(t-2)}{CMU}\right) \\
&+ CA3 * \ln\left(\frac{CN(t-3)}{CMU}\right) + CY * YE(t) + CSD * CZ(t)
\end{aligned}
\tag{3.4.19}
$$

The best estimates of each parameter recommended by Wilkie are as follows:

CW=1.0;CD=0.045;CMU=0.035;$CA1$=1.20;$CA2$=0.48; $CA3$=0.20;CY=0.06;CSD=0.14

3.5 Summary and Conclusions

In the past decade, DFA has gradually emerged as one of the most important approaches to financial modelling. DFA can be applied to assist actuaries in testing the financial condition of insurance companies, evaluating management strategies, allocating capital and surplus, and so on. A number of researches have been carried out to explore the possible application of DFA in many aspects of insurance operations.

This chapter has reviewed the whole process of DFA and particular attention is paid to some of the steps of the process. The whole process of DFA, as outlined in Section 3.2, consists of nine main steps, regardless of its purpose. The process starts with the investigation of the risks faced by the company and current practices of DFA. Before actually building a DFA model, the actuary should be alert to the risk factors to which the company is exposed and identify the possible material threats to company solvency and performance. The next step is to choose one or more appropriate performance and risk measures based upon the purpose of the DFA exercise. Besides, determining the projection period of DFA is also important. The DFA projection period depends on the characteristics of the risks. In general, the projection period should be long enough to capture the full effects of the risks to which the company is exposed.

There are two main DFA techniques, scenario testing and stochastic simulation. Both techniques have individual advantages and disadvantages. Take stochastic simulation as an example. In general, the actuary has to use one or more driving factors and adopt a cascade structure in order to serve the purpose of consistency while modelling assets, liabilities and investment incomes. The driving factors and cascade structure are central parts of DFA and are illustrated in two examples, the DynaMo and the Wilkie investment model. Once the model is built, thousands of iterations of financial results are generated and output distributions of the results are produced. The results should be carefully discussed and interpreted. If some material risks are identified, alternative possible corrective measures should be suggested. Finally, a written report on the DFA exercise should be prepared and be presented to the Board.

In Chapter two, it has been suggested that the investigation of the current practices of DFA/DST/FCR is one of the areas where further empirical research is necessary. The discussion in Chapter three further suggests one more area requiring further research. This area concerns how actuaries identify the risk factors which affect insurer performance and that should be considered being included in DFA applications. In general, actuaries are alert to these factors based on their understanding of company risk exposure and professional judgement. However, it would be preferable if an econometric analysis could be conducted to assist actuaries in identifying these factors.

Chapter Four

The Determinants of Insurance Company Performance: Literature Review and Hypothesis Formulation

4.1 Introduction

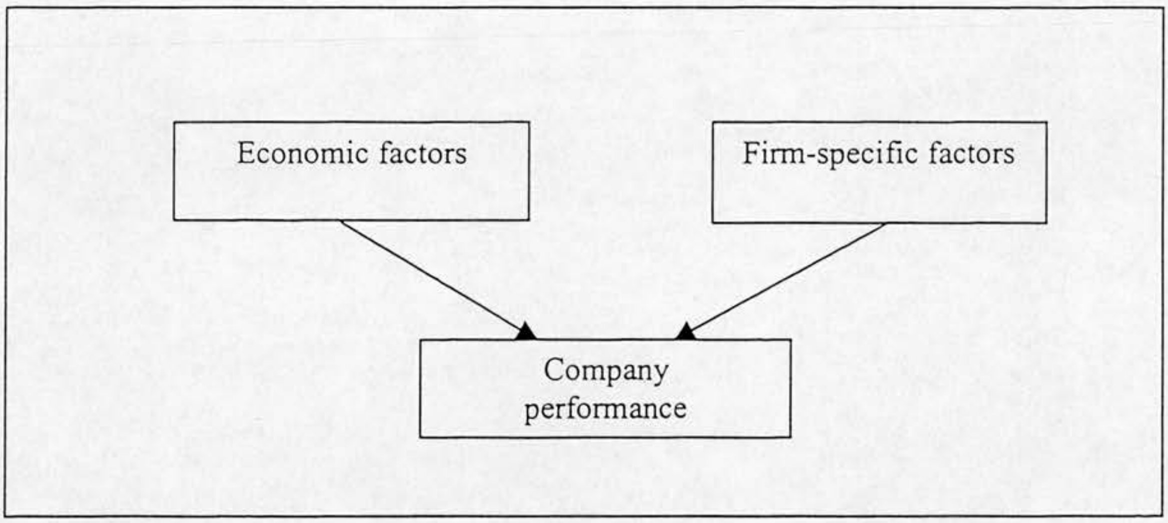
In the previous chapter, one of the areas requiring further research is concerned with how actuaries identify the risk factors which affect company performance and that should be considered being included in DFA applications. In this thesis, the factors which have a material impact on company performance are referred to as the determinants of company performance. In order to address this issue on the identification of the determinants, a diverse range of literature is reviewed. The purpose of this chapter is twofold: (1) to describe and evaluate the theoretical and empirical research relating to the determinants of company performance and (2) to formulate a number of hypotheses, which will then be empirically tested in Chapter eight.

A simple framework of the determinants of company performance is shown in Figure 4.1. Previous studies have shown that a wide range of economic and firm-specific factors may have an impact on company performance. Economic factors such as interest rate levels and equity returns, are largely outside of the control of the company. In contrast with economic factors, firm-specific factors, such as company size, leverage and asset structure, are in general under the company's control.

It should be noted that these determinants are the factors which are statistically associated with company performance. It does not necessarily mean that there is economic causation between the determinants and company performance.

The remainder of this chapter proceeds as follows. Section 4.2 reviews a number of important empirical studies in connection with the determinants of insurance company performance. The literature reviewed in this section is restricted to insurance studies. Section 4.3 briefly describes ten commonly seen performance measures including investment yield, percentage change in shareholders' funds, return on shareholders' funds, and combined ratio which will be used in the empirical analyses in Chapter eight. Section 4.4 discusses a wide range of economic and firm-specific factors which may affect insurance company performance, and formulates relevant hypotheses. The literature reviewed in this section is not necessarily restricted to insurance studies. Section 4.5 summarises and concludes this chapter.

Figure 4.1: A Framework of the determinants of company performance



4.2 Empirical Studies

As shown in Figure 4.1, company performance is affected by both economic and firm-specific factors. The study by Browne and Hoyt (1995) was one of the first studies to identify factors exogenous to individual property-liability insurance companies that increase their susceptibility to insolvency. Insolvency can be regarded as the worst performance of companies, and is defined as the involuntary retirement of an insurance company, including companies that were ordered to liquidate, were placed in receivership, or were placed in conservatorship. Logistic regression is used to estimate the following equation:

$$\ln\left[r_t \big/ (1 - r_t) \right] = \beta_0 + \beta_1 N_t + \beta_2 \Delta i_t + \beta_3 i_t + \beta_4 R_t + \beta_5 U_t + \beta_6 Q1_t + e_t \qquad (4.2.1)$$

where β_i is the estimated coefficient, e is the error term, r is the insolvency rate and is defined as the ratio of the number of insolvent insurance companies n to the total number of insurance companies N, $ln[r_t/(1-\ \ _t)]$ is the logit transformation, i is the three-year average portfolio interest rate, i_t is the interest rate change from quarter t-1 to quarter t, R is the combined ratio, U is the unanticipated inflation rate, and $Q1_t$ is an indicator variable equal to 1 if time period t is the first quarter of the calendar year and zero otherwise.

Using the quarter data for the period from the first quarter of 1970 through the last quarter of 1990, Browne and Hoyt (1995) report that US property-liability insurance company insolvency is significantly and positively related to the number of property-liability insurance companies, the industry combined ratio and the quarter of the year. Nevertheless, the rest of the explanatory variables including the change in interest rates, interest rate and unanticipated inflation are insignificant at the 0.01 level.

Browne, Carson and Hoyt (1999) conduct a similar study on the identification of factors exogenous to individual life-health insurance companies that are statistically related to the overall insolvency rate. Unlike Browne and Hoyt (1995), Browne, Carson and Hoyt (1999) use the log-linear Poisson distribution to estimate the following equation based on the fact that the values for the dependent variable, the number of insolvencies, are discrete and usually small.

$$
\begin{aligned}
\ln\left\{\frac{\mu(x)}{N(x)}\right\} = {} & \beta_0 + \beta_1\Delta^2(AAAAVG)_t + \beta_2\Delta(YCURVE)_t + \beta_3 TB3CHG_t \\
& + \beta_4\Delta(\Delta PI)_t + \beta_5\Delta(UNEMP)_t + \beta_6 REIT_t + \beta_7\Delta(S\ \&\ P)_t \\
& + \beta_8 UNANINF_t + \beta_9 N_t + \beta_{10} Q2_t + \beta_{11} TIME_t + e_t
\end{aligned} \tag{4.2.2}
$$

where $\mu(x)$ is the expected value of the number of insolvencies, x is the vector of explanatory variables, $N(x)$ is the total number of insurance companies, β_i is the estimated coefficient, $^2(AAAAVG)_t$ is the second difference of the arithmetic average of the AAA bond rate during quarter t and the 11 preceding quarters, $(YCURVE)_t$ is the first difference of the log ((1+20 year T-BOND/100) / (1+TB3/100)), $TB3CHG_t$ is the change in the three-month T-bill rate from quarter t-1 to t, $(\ PI)_t$ is the first difference of disposable personal income per capita in quarter t, $(UNEMP)_t$ is the first difference of the percentage of unemployed civilian workers during quarter t, $REIT_t$ is the total rate of return on real estate investment trusts during quarter t, $(S\&P)_t$ is the first difference of the Standard and Poor's 500 index during quarter t, $UNANINF_t$ is the nominal inflation rate over the past three years minus the three-year Treasury yield at the beginning of the three-year period, $Q2$ is an indicator variable equal to 1 if time period t is the second quarter of the calendar year and zero otherwise, $TIME_t$ is a control variable equal to the number of each quarter examined (three through 92) to account for possible changes over time, and e_t is the error term.

Analysing the quarter data for the period from the first quarter of 1972 through the last quarter of 1994, Browne, Carson and Hoyt (1999) found that US life-health insurance company insolvency is significantly and positively related to the first difference of disposable personal income per capita, the number of life-health insurance companies, second quarter dummy and quarter number. However, the rest of the explanatory variables in their model are insignificant at the 0.05 level.

It is interesting to compare the similarities and differences of the findings of Brown and Hoyt (1995), and Brown, Carson and Hoyt (1999). The primary similarity is that both property-liability and life-health insurance company insolvencies are significantly positively to the number of companies at the 0.05 level. The main difference is that Brown and Hoyt (1995) find evidence of an increased insolvency rate in the first quarter of the year for property-casualty insurance companies, whereas Brown, Carson and Hoyt (1999) find evidence of an increased insolvency rate in the second quarter of the year for life-health insurance companies.

Based on annual data from 1985 through 1995 for 1,593 life insurance companies, Browne, Carson and Hoyt (2001) identify important exogenous and insurer-specific factors related to life insurance company performance. Three performance measures are used. These are percentage change in capital and surplus, return on assets and return on equity. The results are largely consistent between the last two measures, but are somewhat less consistent with the results for percentage change in capital and surplus.

Adams and Buckle (2000) identify the determinants of operational performance in the Bermuda insurance market using panel data for the period from 1993 through 1997. A two-way random-effects model is estimated. They find that operational performance is positively related to leverage and underwriting risk, but is negatively related to asset liquidity.

Although it is not stated in Browne and Hoyt (1995), the reason why a logistic regression model is used in their work is because the insolvency rate itself is not suitable for being the dependent variable in (4.2.1). The insolvency rate ranges between 0 and 1. However, since the right-hand side of (4.2.1) could be less than 0 or greater than 1 for certain values of the independent variables identified, predicted probabilities that are either less than 0 or greater than 1 could be obtained, which is impossible. Therefore, the logistic transformation of the insolvency rate is used as the dependent variable.

Browne, Carson and Hoyt (1999) argue that the use of Poisson regression is more appropriate than that of ordinary least squares regression for the following reasons. First, insolvent events are infrequent and the insolvency data are count data. Second, many of the values for the dependent variable are very small or equal to zero. Finally, the dependent variable is of a discrete nature.

Browne, Carson and Hoyt (2001), and Adams and Buckle (2000) identify the determinants of company performance using panel data models. The advantages of panel data will be discussed in the next chapter.

Table 4.1 summarises the dependent and explanatory variables, which have been considered in the empirical analyses in the insurance literature. This table can also serve as a checklist for the actuary to consider whether his or her company's DFA project should include these variables.

Table 4.1: Empirical studies regarding the determinants of insurance company performance

Researchers	Nature of Sample	Methodology	Dependent variable	Explanatory variable Significant at the 5% level*
Browne and Hoyt (1995)	Quarterly data of US property-liability insurance companies for the period 1970 through 1990	Logistic regression model	Insolvency rate	1. Number of companies (+) 2. Industry combined ratio (+) 3. First quarter of the year(+)
Browne, Carson and Hoyt (1999)	Quarterly data of US life-health insurance companies for the period 1972 through 1994	Poisson regression model	Insolvency rate	1. (Disposable personal income per capita) (+/–) 2. Number of insurers (+) 3. Second quarter dummy (+) 4. Quarter number (+/–)
Browne, Carson and Hoyt (2001)	Annual data of US life insurance companies for the period 1985 through 1995	One-way fixed-effects model	Percentage change in capital and surplus	1. (Separate Accounts) / (Total assets) (–) 2. Log (Total assets) (+) 3. (Written premiums) / Surplus (–) 4. Reserves/ (Capital and surplus) (–) 5. IRIS 9 (Surplus relief) (–)
		One-way random-effects model	Return on assets	1. Disposal personal income (+/–) 2. (Liquid assets)/ (Total assets) (+) 3. (Real Estate)/ (Total assets) (–) 4. (Separate Accounts)/ (Total assets) (–) 5. (Ordinary life reserves)/ (Total reserves) (+/–) 6. (Annuity reserves)/ (Total reserves) (+/–) 7. (Written premiums)/ Surplus (–) 8. Reserves/ (Capital and surplus) (–) 9. IRIS 6 (Non-admitted to admitted assets) (–) 10. IRIS 10 (Change in premium) (–)

Table 4.1: Empirical studies regarding the determinants of insurance company performance (continued)

Researchers	Nature of Sample	Methodology	Dependent variable	Explanatory variable Significant at the 5% level*
Browne, Carson and Hoyt (2001)	Annual data of US life insurance companies for the period 1985 through 1995	One-way random-effects model	Return on equity	1. Disposal personal income (+/–) 2. Unanticipated inflation (–) 3. Bond portfolio returns (+/–) 4. (Separate Accounts)/ (Total assets) (–) 5. Log (Total assets) (+) 6. (Ordinary life reserves)/ (Total reserves) (+/–) 7. (Written premiums)/ Surplus (–) 8. Reserves/ (Capital and surplus) (–) 9. IRIS 9 (Surplus Relief) (–) 10. IRIS 10 (Change in premium) (–)
Adams and Buckle (2000)	Accounting data of 47 major non-captive registered insurance and reinsurance companies for the period 1993 through 1997	Two-way random-effects model	Percentage difference between the ratio of annual operating expenses (including commission) plus net premiums written and the ratio of net investment income to net premiums earned	1. Underwriting risk (–) 2. Leverage (+) 3. Liquidity (–) 4. Company type (Direct insurance company = 0, reinsurance company =1) (+)

* The sign in the parenthesis after each significant explanatory variable indicates hypothesised relationship between dependent and the explanatory variables.

4.3 Performance Measures

As stated in Chapter three, the first step of conducting a DFA is to choose appropriate performance measures. This step is also necessary and important for identifying the determinants of company performance. There is a wide range of performance measures currently used in the insurance industry. These measures can be categorised in a number of ways. For instance, Klumpes (2000) discusses two types of performance measures, accounting and actuarial performance measures. As their names suggest, accounting performance measures are generally based on statutory accounting data, whereas actuarial performance measures involve actuarial judgement and techniques. To be more specific, accounting performance measures usually involve traditional accounting techniques to assess past company performance and these measures are therefore backward looking. By contrast, actuarial performance measures usually involve actuarial judgement and techniques to evaluate likely future company performance and these measures are therefore forward looking.

Performance measures can also be categorised in terms of the aspects of insurance operations that the measures evaluate. Some measures are used only to evaluate the investment performance or underwriting performance of an insurance company, whereas others are designed to evaluate its overall performance. Ten commonly seen performance measures are listed and discussed below. For comparison reasons, some of the performance measures, which have been partly discussed in Chapter two, are still listed here and further discussed.

1. Investment Yield

The investment yield is an indicator of the profitability and quality of investment portfolios held by a company. This indicator is defined as follows:

Investment yield = {(Net investment incomes)$_t$ [0.5*((Adjusted total assets)$_{t-1}$

+ (Adjusted total assets) $_t$)]}*100%   (4.3.1)

where adjusted total assets are total assets minus the sum of reinsurers' share of technical provisions and deferred acquisition costs. Since net investment incomes are a flow figure and adjusted total assets are a snapshot figure, investment yield is usually defined as net investment incomes divided by the average assets at the end of the prior year and the current year. The reason why investment yield is calculated in this way is that the company may continuously acquire large amounts of assets using the capital newly raised during the period of year t to year t-1. Therefore part of the year's investment incomes is a return of new assets. Similar usage can be found in some of the following formulas.

2. Loss Ratio

The loss ratio, also known as the claim ratio, is a performance measure of the loss development of underwriting operations of an insurance company. This ratio is defined as follows:

Loss ratio = [(Incurred losses + Claim management expenses)

(Premiums earned)]*100%   (4.3.2)

Incurred losses are the losses occurring during a period of time. It should be noted that it is conventional to include claim management expenses, also known as claim-handling expenses incurred, into the calculation for loss ratio. Premiums earned are the portions of premiums that represent coverage already provided and that belong to the insurance company based on the parts of the policy periods that have passed. Loss ratio is not a complete measure of underwriting performance because it does not include other expenses of underwriting operations except claim management expenses (Lamm-Tennant and Starks, 1993).

3. Expense Ratio

The expense ratio is an indicator of the efficiency of insurance operations of an insurance company. Comparisons of expense ratios among successive time periods indicate overall expense trends and can flag the need for increased attention to cost control (Troxel and Bouchie, 1995). This ratio is defined as follows:

Expense ratio = [Expenses / (Premiums written)]* 100% (4.3.3)

Expenses mainly mean commissions and administration expenses, whereas claim management expenses are usually excluded. As stated in formula (4.3.2), claim management expenses are usually regarded as a component of loss ratio. Premiums written are the premiums due in respect of policies whose coverage incepted during a period of time.

4. Combined Ratio

The combined ratio, also known as the operating ratio, is a complete indicator of the underwriting performance of an insurance company[1]. A combined ratio of less than 100 per cent indicates that the company is generating underwriting profit. Combined ratio is defined as the sum of loss ratio and expense ratio.

Combined ratio = (Loss ratio) + (Expense ratio) (4.3.4)

In order not to blur the additivity of loss ratio and expense ratio, the denominator of expense ratio, written premiums, is sometimes replaced by earned premiums (Daykin et al., 1994). Nevertheless, it seems to be more appropriate to use premiums written as the denominator of expense ratio, instead of earned premiums, in view of the fact that the

[1] Underwriting profit margin is another commonly seen indicator of underwriting performance and is defined as 1 minus combined ratio.

largest components of expenses are commissions, which are usually incurred at the issue or renewal of policies.

5. Overall Operating Ratio

The overall operating ratio is an indicator of the overall performance of an insurance company, including both investment and underwriting operations. This ratio is defined as the difference between combined ratio and investment income ratio.

$$\text{Overall operating ratio} = (\text{Combined ratio}) - (\text{Investment income ratio}) \qquad (4.3.5)$$

where investment income ratio is defined as the ratio of net investment incomes to earned premiums. It should be noted that the lower the value of overall operating ratio, the better the overall profitability of an insurance company. An overall operating ratio of less than 100 per cent indicates that the company is generating pre-tax profit.

6. Return on Assets

Return on assets (ROA) is frequently used to measure the performance of the company and mainly focuses on the ability of management to utilise the total assets of the company in order to generate profits. This ratio is defined as follows:

$$\text{ROA} = \{[(\text{EBIT} - \text{Tax}) / [0.5*((\text{Total assets})_{t-1} + (\text{Total assets})_t)]\}*100\% \qquad (4.3.6)$$

where EBIT denotes earnings before interest and tax.

The numerator of this ratio is EBIT less tax. The reason why the items of interests of debts are not deducted from the profits is because ROA is designed to measure the ability of management to generate profits using the total assets of the company. Therefore, the source of the assets utilised to generate profits is not the main concern in this case. As to the items of taxes, they are deducted from the profits because taxation is controlled externally, not by management.

Browne, Carson and Hoyt (2001) use ROA as one of the dependent variables to measure financial performance of life insurance companies. In their paper, ROA is defined as net income divided by total assets. However, using net income, defined as (EBIT– interest – tax) instead of (EBIT – tax) as the numerator of the ratio ignores the profits that are paid out to debtholders as interest and should therefore not be used to compare firms with different capital structures (Brealey and Myers, 2000).

7. Percentage Change in Shareholders' Funds

Shareholders' funds, also known as solvency margin and surplus in the UK and USA respectively, are the excess of assets over liabilities and mainly consist of equity capital and profit of financial year. Since shareholders' funds are usually regarded as a financial cushion, their variants of measures are supposed to be good indicators of financial strength of an insurance company. Empirical evidence by Carson and Hoyt (1995) has confirmed that surplus measures are strong indicators of insurer financial strength. Browne, Carson and Hoyt (2001) also use percentage change in capital and surplus to measure the financial performance of life insurance companies. At first glance, it seemed to me that a double counting occurred in the denominator since surplus usually includes capital. Carson, one of the authors of Browne, Carson and Hoyt (2001), responded to my query and explained that the two terms, "surplus" and "surplus and capital", are used interchangeably to mean the same thing. Their use of the term capital and surplus just clarifies that capital is also counted. In order to avoid confusion, it would be better to use percentage change in shareholders' funds to measure the percentage change in the degrees of the financial strength of the company than percentage change in surplus or percentage change in surplus and capital. Percentage change in shareholders' funds is defined as follows:

Percentage change in shareholders' funds

$$= \{[(\text{Shareholders' funds})_{t} - (\text{Shareholders' funds})_{t-1}] / (\text{Shareholders' funds})_{t-1}\} * 100\% \quad (4.3.7)$$

It should be noted that this measure is actually the same as the NAIC Property/Casualty IRIS Ratio 7 (Change in policyholders' surplus) (National Association of Insurance Commissioners, 2001a) and the NAIC Life/Health IRIS Ratio 2 (Gross change in capital and surplus) (National Association of Insurance Commissioners, 2001b).

8. Return on Shareholders' Funds

The return on shareholders' funds (RSF) is also a common indicator of company performance and mainly focuses on the return on the company's shareholders' funds. This ratio is defined as follows:

$$\text{Return on shareholders' funds} = \{(\text{Profit before tax}) / [0.5*((\text{Shareholders' funds})_{t-1} + (\text{Shareholders' funds})_{t})]\} * 100\% \quad (4.3.8)$$

Return on equity (ROE), which is the same as RSF by definition, is one of the performance measures that Browne, Carson and Hoyt (2001) use. Like ROA, their ROE is defined as net income divided by surplus and capital, which sometimes might cause confusion.

9. Economic Value Added

Like ROA and RSF, Economic Value Added[2] (EVA®) is also an accounting-based estimate of the financial performance of a company. This term is defined as follows:

---

[2] Economic Value Added is a financial performance measure developed by an US-based consulting company, Stern Steward & Co. See http://www.sternstewart.com/ for details.

$$EVA^{®} = \text{Net income} - (\text{Capital} * \text{Cost of capital}) \quad (4.3.9)$$

where cost of capital is the expected return which is forgone by investing in a project rather than in comparable financial securities (Brealey and Myers, 2000).

From the above definition, it is apparent that EVA® is an estimate of economic profit of dollar amount. In contrast with ROA and RSF, EVA® explicitly takes into account cost of capital employed to produce the profit. Positive EVA® means that management has created economic value for shareholders, whereas negative EVA® destroyed. Therefore, EVA® is regarded as a good management tool to evaluate and reward management's performance and has been gradually accepted in many industries. Moreover, EVA® can also be applied to measure performance of a company as a whole (Brealey and Myers, 2000).

10. Embedded Value

In contrast with the aforementioned indicators, embedded value is a relatively new performance measure. Simply speaking, embedded value is an actuarially determined estimate of the economic value of an insurance company, excluding any value that may be attributed to future new business. Embedded value consists of value of in-force business and value of free shareholder equity. According to the Canadian Institute of Actuaries (2000) embedded value is defined as the sum of the present value of the following three components.

- Future shareholders' after-tax income (operating income attributable to shareholders, including investment income on locked-in capital)
- Future changes in locked-in capital
- Any free capital, as at the valuation date

The discounted rate utilised to discount the above-mentioned components should reflect current long-term risk free interest rates plus an estimate of the risk premium demanded by investors. Locked-in capital refers to the amount of capital that the company has set aside (i.e., not immediately distributable) to support its in-force business. Free capital refers to the after-tax market value of the capital in excess of the locked-in capital as at the valuation date.

In recent years embedded value has gradually become a popular proxy for the value of an insurance company. In fact, the embedded value of an insurance company broadly represents the value of the company if it were to stop writing new business (Arabeyre and Hardwick, 2001). If embedded value is calculated on a regular basis, the changes in embedded value from year to year can serve as an alternative performance measure for individual companies.

Although embedded value seems to be a useful measure, it has its own limitations. For instance, it is unavoidable that many assumptions are employed in the calculations of embedded value because it is an actuarially determined estimate. These assumptions that are sometimes very debatable include mortality, persistency, expenses, persistency and discount rate. For instance, the choice of discount rate is somewhat subjective. Discount rate comprises long-term risk free interest rate and risk premium. Risk premium that is the source of subjectivity usually reflects the risk appetite of the investors. However, some arguments have been made that the risk premium should reflect the risk inherent in the product that is being modelled, not the risk appetite of the investor (PricewaterhouseCoopers, 2001).

Since the assumptions set by different actuaries vary and embedded value could be very sensitive to the assumptions, it is difficult to compare embedded values of different companies.

The above-mentioned ten performance measures are classified in terms of techniques involved and aspects of operations measured and are summarised in Table 4.2. All these performance measures involve traditional accounting techniques to assess past company performance, except for embedded value. With regard to the aspects of insurance operations measured, investment yield evaluates investment performance, whereas loss ratio, expense ratio, and combined ratio assess different aspects of underwriting operations. The rest performance measures are used for evaluating the overall performance of an insurance company.

Table 4.2: Classifications of performance measures

Criterion / Performance Measure	Techniques involved		Aspects of operations measured		
	Accounting performance	Actuarial performance	Investment performance	Underwriting performance	Overall performance
Investment yield	*		*		
Loss ratio	*			*	
Expense ratio	*			*	
Combined ratio	*			*	
Overall operating ratio	*				*
Return on assets	*				*
Percentage change in shareholders' funds	*				*
Return on shareholders' funds	*				*
Economic value added	*				*
Embedded value		*			*

4.4 Economic and Firm-Specific Factors

Insurance is a very complicated business. A wide range of economic and firm-specific factors could be statistically related to the financial performance and strength of an insurance company. Daykin et al. (1994) list several factors on which financial strength rests such as underwriting, investments, solvency margin and reinsurance. The following discussion is largely in line with but not limited to the above-mentioned factors.

4.4.1 Economic Factors

1. Unexpected inflation

Inflation certainly plays a role in insurance and has adverse impact on many aspects of insurance operations, such as claims, expenses and technical reserves (Daykin, Pentikäinen and Pesonen, 1994). However, because UK inflation has been relatively small and predictable over the years, and expected inflation is taken into account when premiums are set, inflation itself is unlikely to seriously impact on the performance of insurance companies. Nevertheless, if inflation is significantly greater than expected, it could cause insurance companies financial difficulty.

For instance, unexpected inflation makes real returns on fixed-rate bonds lower than expected. As a consequence, profit margins of insurance companies are compressed and financial performance is accordingly impaired (Browne, Carson and Hoyt, 1999). This is relatively obvious in a life insurance context.

Since equities account for a high proportion of the investment holdings of the UK insurance companies, it would be interesting to investigate the relationships between inflation and equity returns, and between unexpected inflation and equity returns. According to Fisher's prediction, there is a positive relationship between expected inflation and nominal asset returns. Buying equities has been traditionally seen as a hedge against inflation and this is one of the main reasons why insurance companies invest in equities. However, many studies find a negative relationship between inflation and equity returns (See, for example, Fama and Schwert (1977); Amihud (1996); Reilly

(1997)). Some hypotheses have been put forward to try to justify this negative relationship (Pearce and Roley, 1988). Nowadays, the general conclusion is that equities are not a perfect hedge against inflation and equity returns are negatively related to inflation (Giammarino, 1998).

As to the relationship between unexpected inflation and equity returns, Pearce and Roley (1988) provide evidence that a share's response to unexpected inflation depends on the characteristics of the company. Their main findings can be summarised as follows:

(1) Different shares respond to unexpected inflation differently, and both positive and negative stock returns are recorded. However, the average response of equity returns to a one per cent unexpected inflation is between –2.25 per cent and 0.

(2) Time-varying company characteristics related to inflation, such as debt-equity ratio and inventories, appear to be particularly important in determining the response.

Given the negative relationship between unexpected inflation and bond returns, and between unexpected inflation and equity returns, it is expected that the relationship between company performance and unexpected inflation would be negative. Nevertheless, it should be noted that the impact of unexpected inflation on the performance of non-life companies is generally less than that on the performance of life companies because most of the assets and liabilities of non-life insurance companies are short-term, especially in the countries where the short-term forecast of inflation is relatively reliable and predictable (Booth et al., 1999).

Browne, Carson and Hoyt (2001) provide some supportive evidence that periods of higher unexpected inflation produce reduced financial performance in US life insurance companies. However, no similar significant relationship between unexpected inflation and the insolvency rate is found in Browne and Hoyt (1995) for the US property-liability insurance companies or in Browne, Carson and Hoyt (1999) for the US life-health insurance companies.

2. Interest rate changes

It has been generally accepted that interest rate risk is one of the main risks faced by insurance companies. Although interest rate changes influence the value of assets and liabilities in the same direction, the impact on assets and liabilities is different if the two have different durations. This risk is likely to be avoided to a great extent if the durations of assets and liabilities are nearly matched. However, life insurance companies often intentionally mismatch the durations by holding assets with longer duration than liabilities to obtain higher returns (Colquitt and Hoyt, 1997). This intentional mismatch results in interest rate risk. In the case of the positive asset-liability duration mismatch, interest rate changes normally have a greater impact on the value of assets than that of liabilities since interest rate risk increases with the term of duration. Therefore, it is expected that the relationship between performance and interest rate changes would be negative for life insurance companies.

Compared with their life counterparts, non-life insurance companies usually invest a high proportion of their funds in short-term investments and tend to match the liabilities with appropriate assets because their liabilities are much shorter and less predictable in amount (Booth et al., 1999; also see Chapter two). Therefore, it seems safe to say that positive asset-liability duration mismatches are less common in the non-life insurance industry than the life insurance industry, although this mismatch still exists for some non-life insurance companies on return grounds. Based on the above discussion, there is no prior expectation about the direction of the relationship between performance and interest rate changes for non-life insurance companies.

Browne, Carson and Hoyt (1999) provide supportive evidence that the US life-health insurance companies are more likely to become insolvent during periods of increases in long-term interest earnings. However, Browne and Hoyt (1995) do not find similar evidence for the US property-liability insurance companies. Browne, Carson and Hoyt (2001) show that there is a negative, though insignificant, relationship between financial performance and interest rate changes in the US life insurance industry.

3. Interest rate level

Table 2.5 in Chapter two shows that the UK non-life insurance industry and life insurance industry as a whole respectively invested 24.4 per cent and 21.2 per cent in bonds during the period 1986-1999. Since bond portfolio accounts for a high proportion of the invested assets of insurance companies, bond investment earnings are important for their investment performance. Bond returns largely depend on the level of interest rates. High interest rates bring high bond investment income, which accordingly enhance the investment performance of insurance companies.

However, from another perspective high interest rates could negatively affect the financial performance of life insurance companies. The reason is that high interest rates could induce policyholders to use the options of policy loans and policy surrenders in order to obtain cash value of the policies to invest in other investment vehicles, which can provide them with higher earnings (Browne, Carson and Hoyt, 1999; 2001).

Based on the discussion above, it is expected that the direction of the relationship between performance and interest rate level would be positive for non-life insurance companies because they usually do not have options of policy loans and surrenders for their products. There is no prior expectation about the direction of the relationship between performance and interest rate level for life insurance companies.

Browne, Carson and Hoyt (2001) provide evidence that the financial performance of the US life insurance companies is significantly improved during periods of high long-term interest earnings. In another study, Browne and Hoyt (1995) find that US property-liability insurance companies are less likely to become insolvent during periods of high interest earnings.

4. Equity returns

Table 2.5 in Chapter two reports that the UK general insurance industry and life insurance industry as a whole respectively invested 12.5 per cent and 33.3 per cent in equities and other shares during the period 1986-1999. In general, high returns on equities enhance the investment performance of insurance companies. Nevertheless, it should be noted that a high proportion of the portfolios in equities could increase insolvency risk (Booth et al., 1999). Moreover, as equity returns increase, life insurance policyholders might surrender their policies or take policy loans, and invest the funds obtained in equity market. This disintermediation could pose liquidity risk to life insurance companies (Browne, Carson and Hoyt, 2001).

Based on the discussion above, it is expected that the direction of the relationship between performance and equity returns would be positive for non-life insurance companies, but there is no prior expectation about the direction of the relationship between performance and equity returns for life insurance companies.

4.4.2 Firm-Specific Factors

1. Company size

It has been suggested that company size is positively related to financial performance. The main reasons behind this can be summarised as follows. First, large insurance companies normally have greater capacity for dealing with adverse market fluctuations than small insurance companies. Second, large insurance companies usually can relatively easily recruit able employees with professional knowledge compared with small insurance companies. Third, large insurance companies have economies of scale in terms of the labour cost, which is the most significant production factor for delivering insurance services.

Browne, Carson and Hoyt (2001) have shown empirically that company size is positively related to financial performance for US life insurance companies. However, company size is not found to be an important determinant of operational performance in the Bermuda insurance market during the period 1993-1997 (Adams and Buckle, 2000). Based on the discussion above, it is expected that the relationship between performance and company size would be positive.

2. Reinsurance dependence

Insurance companies usually take out reinsurance cover to stabilise earnings, increase underwriting capacity and provide protection against catastrophic losses. More importantly, they can reduce underwriting risk by purchasing reinsurance. Furthermore, reinsurance can allow insurance companies specialising in particular lines of business to diversify across lines. Nevertheless, there is a cost for reinsurance. As a result, determining an appropriate retention level is important for insurers, and they have to try to strike a balance between decreasing insolvency risk and reducing potential profitability. Although it increases operational stability, increasing reinsurance dependence, i.e. lowering the retention level, reduces the potential profitability. Therefore, it is expected that the relationship between performance and reinsurance dependence would be negative.

3. Leverage

Insurers collect premiums in advance and keep them in reserve accounts for future claim settlements. For instance, most premiums collected by non-life insurance companies are kept in outstanding claims and unearned premiums reserves which are two main accounts in the liability side of the balance sheet. Outstanding claims reserve is considered riskier than ordinary long-term corporate debt since neither the magnitude nor the timing of the cash flows is known. Unearned premium reserve is similar to ordinary short-term loans because most general insurance policies are short-term and expire in one year (Briys and de Varenne, 2001). Policyholders receive a discount in their premiums to compensate for the opportunity cost of the funds held by insurance companies. Likewise, the discount is similar to the interest payments on corporate debt to policyholders by insurance companies (Berger, Cummins and Weiss, 1997).

Like other ordinary stock companies, stock insurance companies issue debt and equity securities to obtain funds[3]. The choice of capital structure, the combination of different securities, has been one of the most important issues on corporate finance. However, does the so-called optimal capital structure exist? If yes, does the use of debt (financial leverage) increase the expected return on equity?

According to Modigliani and Miller (1958), any combination of securities is as good as the other in perfect capital markets. Modigliani and Miller's (MM's) proposition I states that the overall market value of a company, i.e. the total market value of the debt and equity securities issued by the company, is independent of its capital structure in a perfect market. That is, the overall market value of a company's securities is the same despite the changes in the combination of its securities in a frictionless world with full information and complete markets, and without tax, cost of transaction and financial distress. If MM's proposition I holds, expected return on assets is not affected by the company's debt policy, since neither expected operating income nor total market value of its securities has been changed (Brealey and Myers, 2000). Moreover, MM's proposition II, derived from MM's proposition I, states that the relationship between expected return on equity and debt-equity ratio is positive. That is, the more financial leverage or gearing, the higher expected return on equity with the increase in risk. It

[3] In a mutual insurance company, "equity" does not exist. The net worth of a mutual insurance company is its solvency margin or policyholders' surplus, which is the remaining fund after payments of claims and costs of operations, and belongs to the policyholders.

should be noted that the two propositions do not contradict each other because of the trade-off between risk and return. Nevertheless, almost each aforementioned condition of the perfect capital markets is not met in the real world. Therefore, MM's two propositions do not completely hold and financial leverage might have impact on company performance.

Insurance firms could prosper by taking reasonable leverage risk or could become insolvent if the risk is out of control. Adams and Buckle (2000) provide evidence that insurance companies with high leverage have better operational performance than insurance companies with low leverage. Nevertheless, more empirical evidence supports the view that leverage risk reduces company performance. Carson and Hoyt (1995) find that leverage is significantly positively related to the probability of insolvency. Moreover, a negative relationship between leverage and performance has also been found in Browne, Carson and Hoyt (2001). Based on the above discussion, it is expected that the relationship between performance and leverage would be negative.

4. Affiliated investments

Table 2.5 in Chapter two shows that the UK non-life insurance industry and life insurance industry as a whole respectively invested 12.9 per cent and 1.5 per cent in affiliates during the period 1986-1999. It has been suggested that affiliated investments would increase insolvency risk of parent companies. Thus, it is expected that the relationship between performance and affiliated investments would be negative.

5. Solvency margin or free asset ratio

Solvency margin and free asset ratio are commonly seen indicators of financial soundness for non-life and life insurance companies respectively. Insurance companies with a higher solvency margin or free asset ratio are considered to be more sound financially. Financially sound insurance companies are better able to attract prospective policyholders[4] and are better able to adhere to the specified underwriting guidelines. In general, by adhering to the guidelines, the insurance companies can expect a better underwriting result because the guidelines are "best practices" for the type of business and market segment involved[5]. Therefore, it is expected that both the relationship between performance and solvency margin for non-life insurance companies, and the relationship between performance and free asset ratio for life insurance companies, would be positive.

6. Stability of underwriting operation

Huge fluctuations in net premiums written indicate a lack of stability in underwriting operation of an insurance company. An unusual increase in net premiums written might indicate that the company is engaging in the so-called "cash-flow underwriting" to attempt to survive its financial difficulty. However, this is not necessarily the case and an alternative hypothesis can be formulated as follows. An unusual increase in net premiums written could indicate favourable business expansion if it is accompanied by adequate reserving, profitable operations, and stable products mix (National Association of Insurance Commissioners, 2001a)[6]. The indicator of annual change in net premiums written is similar to the NAIC Life/Health Insurance Regulatory Information System (IRIS) Ratio 10 (Change in premium) and the NAIC Property/Casualty IRIS Ratio 3 (Change in net writings). Its usual range of values is between –33 per cent and 33 per cent (National Association of Insurance Commissioners, 2001a; 2001b). The wide and equal both positive and negative ranges of normal values indicate that this indicator is not a very sensitive predictor of performance. Based on the above discussion, there is no

[4] However, it should be noted that for some non-life personal lines such as motor insurance it is the price that dictates the attractiveness to prospective policyholders rather than the financial soundness of the company.
[5] It is worth mentioning that adhering to underwriting guidelines will not necessarily help to improve underwriting results unless they are appropriate for the business.
[6] There are some other possible reasons why the net premiums written increase. For instance, the net premiums may go up dramatically if less reinsurance is purchased. Besides, "underwriting cycle" may play a part in the increase/decrease in the net premiums written. In a hard market, premium rates are high and accordingly net premiums may increase.

prior expectation about the direction of the relationship between performance and stability of underwriting operation.

7. Liquidity

Assets can be divided into liquid and illiquid assets in terms of liquidity. Companies with more liquid assets are less likely to fail because they can realise cash even in very difficult situations. It is therefore expected that insurance companies with more liquid assets will outperform those with less liquid assets. Browne, Carson and Hoyt (2001) provide evidence supporting that performance is positively related to the proportion of liquid assets in the asset mix of an insurance company.

However, an alternative hypothesis can be formulated as follows. Maintaining high liquidity can reduce management's discipline as regards both underwriting and investment operations. Moreover, according to the theory of agency costs, high liquidity of assets could increase agency costs for owners because managers might take advantage of the benefits of liquid assets (Adams and Buckle, 2000). In addition, liquid assets imply high reinvestment risk since the proceeds from liquid assets would have to be reinvested after a relatively short period of time. Undoubtedly, reinvestment risk would put a strain on the performance of a company. In this case, it is, therefore, likely that insurance companies with less liquid assets outperform those with more liquid assets. Nevertheless, agency costs and reinvestment risk can be effectively minimised if proper actions are taken.

Based on the above discussion, it is expected that the relationship between performance and asset liquidity would be positive.

8. Stability of asset structure

Dramatic changes in asset structure indicate a lack of stability in the investment operations of an insurance company. An unusual change in asset structure might indicate that the company is rearranging its asset structure due to solvency concerns (Carson and Hoyt, 1995). Indicators of change in asset mix are the NAIC Life/Health IRIS Ratio 12 and the NAIC fraternal society IRIS Ratio 11. Its usual range of values is less than 5 per cent (NAIC, 2001a, 2001c). Based on the above discussion, it is expected that the relationship between performance and change in asset mix would be negative. That is, it is expected that the relationship between performance and stability of asset structure would be positive.

9. Asset / product mix

All important asset categories have been considered previously except the category of assets held to cover linked liabilities. According to Table 2.5 in Chapter two, 31.1 per cent of the assets of the life insurance industry as a whole were held to cover linked liabilities during the period 1986-1999. Since the industry invested a high proportion of its funds in assets held to cover linked liabilities, they might affect company performance. However, there is no expectation about the direction of the relationship between performance and assets held to cover linked liabilities.

An insurance company's product mix represents its liability structure. Like asset mix, the product mix might also affect company performance. Again, there is no expectation about the direction of the relationship between performance and product mix. Browne, Carson and Hoyt (2001) shows that some of the product categories are significantly negatively related to financial performance for US life insurance companies.

According to the above discussion in this section, the following hypotheses are proposed. In addition, the previous comments concerning each hypothesis are summarised below.

Hypothesis 1: Other things being equal, it is expected that the relationship between performance and unexpected inflation would be negative.

As indicated in Chapter two, during the period 1986 through 1999 the non-life and life insurance sectors invested 24.4 per cent and 21.2 per cent in bonds, and 12.5 per cent and 33.3 per cent in equities respectively. Unexpected inflation has an adverse impact on both bond and equity returns. Therefore, it is expected that the relationship between performance and unexpected inflation would be negative.

Hypothesis 2: Other things being equal, it is expected that the relationship between performance and interest rate changes would be negative for life insurance companies, but there is no prior expectation about the direction of the relationship between performance and interest rate changes for non-life insurance companies.

Since life insurance companies often intentionally mismatch the durations by holding assets with longer duration than liabilities, interest rate changes normally have a greater impact on the value of assets than that of liabilities. Therefore, it is expected that the relationship between performance and interest rate changes for life insurance companies would be negative. Nevertheless, because the positive asset-liability duration mismatches are less common in the general insurance industry than the life insurance industry, there is no prior expectation about the direction of the relationship.

Hypothesis 3: Other things being equal, it is expected that the relationship between performance and interest rate level would be positive for non-life insurance companies, but there is no prior expectation about the direction of the relationship between performance and interest rate level for life insurance companies.

Because bond portfolio accounts for a high proportion of the invested assets of non-life insurance companies, high interest rates bring high bond investment income. Therefore, it would be expected that the relationship between performance and interest rate level would be positive for non-life companies. Nevertheless, since the products of life insurance companies have the options of policy loans and policy surrenders, high interest rates could induce policyholders to use these options. The financial performance of life companies could be adversely affected due to high interest rates.

Hypothesis 4: Other things being equal, it is expected that the relationship between performance and equity returns would be positive for non-life insurance companies, but there is no prior expectation about the direction of the relationship between performance and equity returns for life insurance companies.

High equity returns enhance the investment performance of insurance companies. However, as mentioned previously, the policyholders of life insurance companies might take policy loans or surrender policies as equity returns increase. Therefore, the hypothesis regarding the relationship between performance and equity returns is similar to the previous one regarding the relationship between performance and interest rate level.

Hypothesis 5: Other things being equal, it is expected that the relationship between performance and company size would be positive.

Large companies normally have greater capacity for dealing with adverse market fluctuations than small companies, can relatively easily recruit able employees, and have economies of scale. Therefore, it is expected that the relationship between performance and company size would be positive.

Hypothesis 6: Other things being equal, it is expected that the relationship between performance and reinsurance dependence would be negative.

Increasing reinsurance dependence reduces the potential profitability. Therefore, it is expected that the relationship between performance and company size would be negative.

Hypothesis 7: Other things being equal, it is expected that the relationship between performance and leverage would be negative.

Although insurers could prosper by taking reasonable leverage risk, they could become insolvent if the risk is out of control. If this is the case, leverage risk could reduce company performance. Therefore, it is expected that the relationship between performance and leverage risk would be negative.

Hypothesis 8: Other things being equal, it is expected that the relationship between performance and affiliated investments would be negative.

Since affiliated investments would increase insolvency risk of parent companies, it is expected that the relationship between performance and affiliated investment would be negative.

Hypothesis 9: Other things being equal, it is expected that both the relationship between performance and solvency margin for non-life insurance companies, and the relationship between performance and free asset ratio for life insurance companies, would be positive.

Since financially sound insurance companies are better able to attract prospective policyholders and are better able to adhere to the specified underwriting guidelines, they can expect a better underwriting result. Therefore, it is expected that both the relationship between performance and solvency margin for non-life companies, and that between performance and free asset ratio for life companies would be positive.

Hypothesis 10: Other things being equal, there is no prior expectation about the direction of the relationship between performance and stability of underwriting operation.

An unusual increase in net premiums written might indicate that the company is attempting to survive its financial difficulty. Nevertheless, it could indicate favourable business expansion. Therefore, there is no prior expectation about the direction of the relationship between performance and stability of underwriting operation.

Hypothesis 11: Other things being equal, it is expected that the relationship between performance and asset liquidity would be positive.

Since insurance firms with more liquid assets are less likely to fail because they can realise cash even in very difficult situation, it is therefore expected that companies with more liquid assets outperform those with less liquid assets.

Hypothesis 12: Other things being equal, it is expected that the relationship between performance and stability of asset structure would be positive.

Since an unusual change in asset structure might indicate the company is rearranging its asset structure due to solvency concerns, it is therefore expected that companies with more stable asset structure outperform those with less stable asset structure.

Hypothesis 13: Other things being equal, there is no prior expectation about the direction of the relationship between performance and asset / product mix variables.

Asset mix and product mix might affect company performance. However, there is no expectation about the direction of the relationship between performance and asset mix or that of the relationship between performance and product mix.

4.5 Summary and Conclusions

Hendry and Richard (1983) point out that any constructed model should be parsimonious no matter what kind of criteria it should satisfy. Since the real insurance operations are very complicated, it is neither possible nor necessary to include all the factors affecting company performance in one DFA model. A good DFA model should capture key risk factors of the past, current and future operations of the company. Therefore, identifying the factors is one of the key steps of conducting a DFA.

Based on the literature reviewed in this chapter, there is a range of economic and firm-specific factors possibly related to insurance company performance. Economic factors, such as interest rate level and equity returns, are outside of the control of the company, whereas firm-specific factors such as company size and asset structure are largely under the company's control. Tables 4.3 and 4.4 summarise the hypotheses about the direction of the relationship between performance and both economic and firm-specific factors for non-life and life insurance companies respectively ("+" indicates a positive relationship, "–" indicates a negative relationship, and a blank indicates no hypothetical relationship). These hypotheses will then be tested in Chapter eight.

Table 4.3: Hypotheses for non-life insurance companies

Hypothesis	Economic / firm-specific factor	Predicted sign
1	Unexpected inflation	–
2	Interest rate changes	
3	Interest rate level	+
4	Equity returns	+
5	Company size	+
6	Reinsurance dependence	–
7	Leverage	–
8	Affiliated investments	–
9	Solvency margin	+
10	Stability of underwriting operation	
11	Liquidity	+
12	Stability of asset structure	+

Table 4.4: Hypotheses for life insurance companies

Hypothesis	Economic / firm-specific factor	Predicted sign
1	Unexpected inflation	–
2	Interest rate changes	–
3	Interest rate level	
4	Equity returns	
5	Company size	+
6	Reinsurance dependence	–
7	Leverage	–
8	Free asset ratio	+
9	Stability of underwriting operation	
10	Liquidity	+
11	Stability of asset structure	+
12	Asset / product mix	

Chapter Five

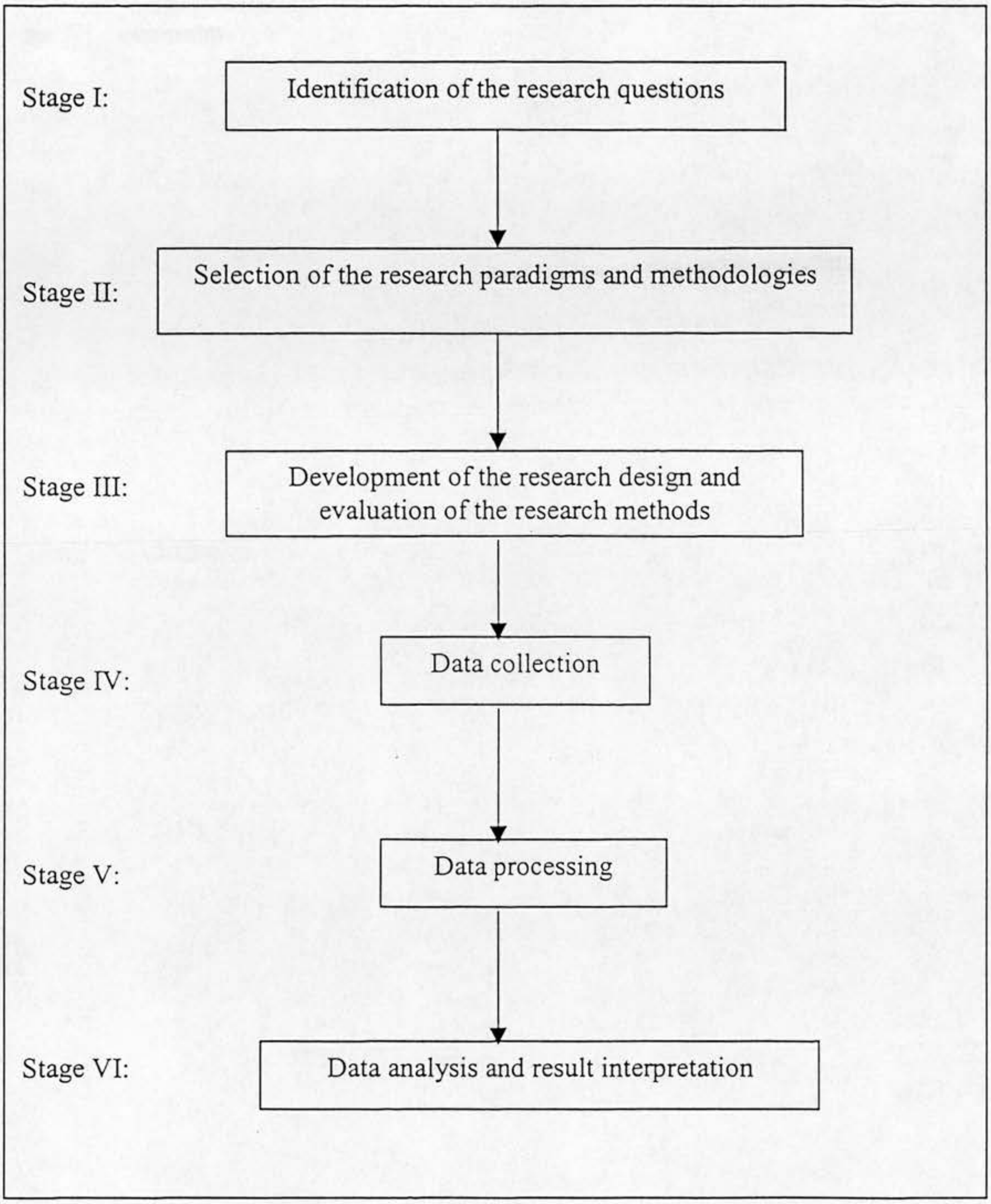
Research Design and Method

5.1 Introduction

According to Patton (1982), the decision about which research paradigm to use has moved from the traditional research focus to the focus on the research question. Yin (1994) also indicates that the first and most important condition for differentiating among the various research strategies is to identify the type of research question being defined. Therefore, in this chapter the two research areas identified in Chapters two and three are converted into the four research questions of the thesis and then followed by the research paradigms and methodologies adopted. The overall research design will then be outlined. Finally the research methods utilised will be presented one by one, and their advantages and disadvantages will be discussed.

Figure 5.1 shows the stages of this research. This chapter focuses on Stages I, II, III and IV and is intended to justify the research methods utilised. The rest of stages will be then discussed in the following empirical chapters of the thesis.

Figure 5.1: The stages of the research

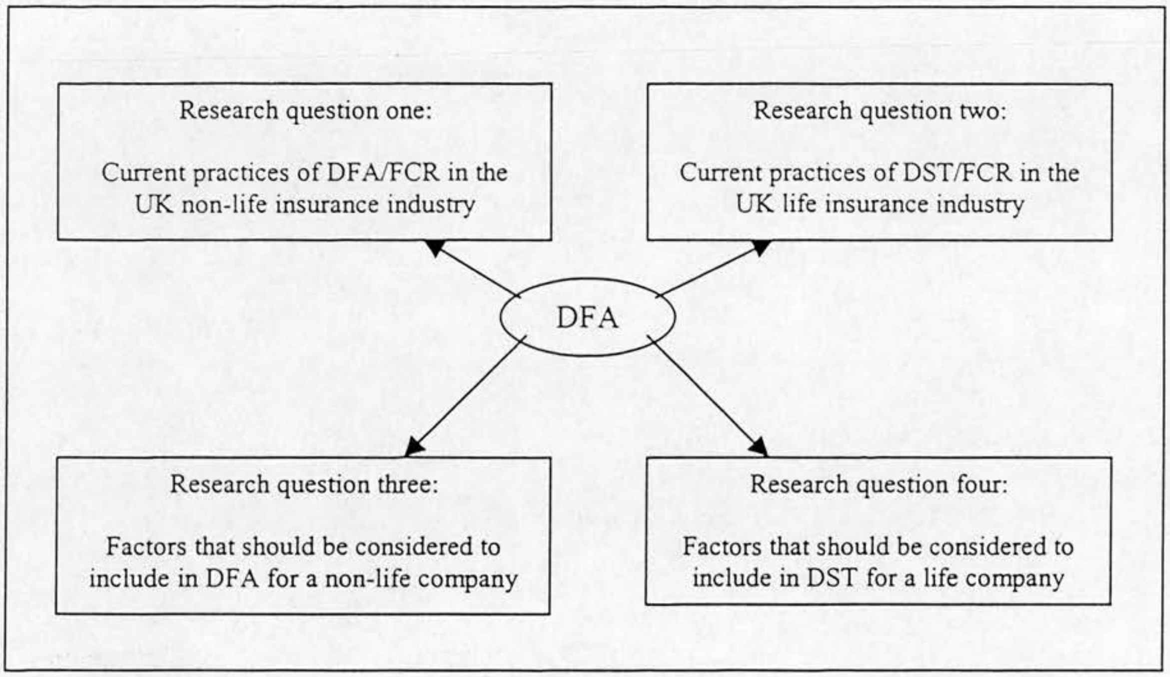


5.1.1 Research Questions

As identified in Chapters two and three, there are two main areas related to Dynamic Financial Analysis (DFA) where further empirical research is necessary. These two main areas include: (1) an up-to-date survey of the current Dynamic Solvency Testing (DST) / Financial Condition Reporting (FCR) practices in the UK insurance companies and friendly societies carrying on long-term business, and a survey of the current DFA/FCR practices in the UK insurance companies carrying on general business, and (2) the performance determinants that should be considered being included in DFA/DST applications.

Research begins with a research question or a set of research questions. Therefore, for research purposes these two identified areas are converted into the following four research questions. These four research questions are all centred around DFA. See Figure 5.2.

Figure 5.2: The research questions



Question one: What are the current practices of DFA and FCR in the UK non-life insurance industry?

Question two: What are the current practices of DST and FCR in the UK life insurance industry?

Question three: Which are the economic and company-specific factors that should be considered being included in DFA for a non-life insurer?

Question four: Which are the economic and company-specific factors that should be considered being included in DST for a life insurer?

It is worthwhile to point out that these four research questions are all closely related to the application of DFA in the UK insurance industry. The empirical results should be of interest to the actuary who is charged with the task of DFA/DST/FCR. The findings of the first two research questions can update the actuary on the current practices and latest development of DFA/DST/FCR in the market. At the commencement of a DFA/DST project, it is important for the actuary to know which risk factors should be included in the project. The identification of the determinants of company performance is instrumental in this step of the DFA/DST process. How to identify these determinants is exactly what the last two research questions try to address. After identifying the company performance determinants which should be included in the DFA/DST project, the actuary will then be able to apply DFA approaches to a given situation.

5.1.2 Research Paradigm and Methodology

During recent years, social science researchers have become increasingly more aware of a variety of research paradigms. Paradigms are shared commitment and belief within a scientific community as to the nature of the legitimate problems, theories, and methods of their discipline (Kuhn, 1970). In this subsection, only two main research paradigms in social science are discussed. These are positivist and interpretative paradigms. Positivism, also known as logical or empirical positivism, is based on objectivity and empiricism, and contains the underlying philosophical assumptions of research in mathematics, physics and biology, etc. According to positivism, knowledge can only be obtained by logical reasoning and empirical experience. The former is analytic a priori, while the latter is synthetic a posteriori; hence synthetic a priori does not exist (Hanfling, 1981). Positivistic researchers strive to be rational and unbiased, and their work is based on real facts that can be proved or experienced. These experiments have to be repeatable and the results obtained should be identical.

The interpretative paradigm stems from hermeneutics and phenomenology. The interpretative philosophy assumes that the reality is socially constructed and can only be understood through social constructions such as human language, action, and shared meanings. Compared with positivism, the interpretative philosophy is more subjective because it contains "human element".

Because of its objectivity, the positivist philosophy is rather appealing to researchers in all fields. Nevertheless, it is in particular difficult to completely follow when applied to the research of social science for, at least, the following two reasons. First, the positivist approach is based on exact observation, which is relatively impossible in social science research since the research of this kind often involves measurement errors, whose extent is difficult to measure. Second, this approach assumes that knowledge is derived from an objective reasoning and interpretation of assumptions without any subjective biases.

Methodology is the science of methods. It is determined by principles of research entailed in a paradigm. Generally speaking, there are two kinds of methodologies. These are quantitative and qualitative methodologies. The most significant difference between the two is that quantitative researchers eagerly pursue objectivity, whereas qualitative researchers reject fundamentally the notion of objectivity (Sarantakos, 1998). From this perspective, quantitative methodology is in general associated with positivist and empirical philosophy, while qualitative methodology interpretative philosophy. Nevertheless, it should be noted that quantitative methodology can be subjective and not completely objective.

As stated previously, due to its objectivity the positivist philosophy is rather appealing to researchers in all fields. In fact, it seems safe to say that research could not have been conducted with the necessary rigour unless the positivist philosophy and quantitative methodology had been adopted. Nevertheless, because a research question is often multi-aspect and can be explored from different perspectives it is necessary to include both positivist and interpretative paradigms, and adopt both quantitative and qualitative methodologies in order to have a deeper understanding of the question. Moreover, sometimes the positivist philosophy and quantitative methodology are simply inappropriate to some social science research.

This thesis is intended to address four research questions stated in the previous subsection. The main body of work is based in the domain of positivist endeavour. With respect to Questions three and four, the positivist paradigm and quantitative methodology are adopted. However, an approach which combines the benefits of both paradigms and both methodologies is adopted to address Questions one and two. The main reason is that it is necessary not only to find out what the current DFA/DST/FCR practices are, but also to know how the DFA/DST techniques are used to thoroughly address the questions.

5.2 Research Design

This research investigates four important questions centred around DFA. Because of the characteristics of these research questions, the synthesised paradigms and methodologies should be adopted, as discussed above. Thus the research design presented here is based on a multi-method approach. Within this research design each phase of the research is conducted using the most appropriate method or set of methods. Each method utilised will be considered one by one in the next section. However, it is worthwhile to put all the research methods utilised within a context in order to have a general picture of the overall research design of this research.

According to the type of the first two research questions, it was decided that an exploratory study was required to deal with these questions. At the time when this research was carried out, relatively little was known about the practices of DFA/DST/FCR. As far as this author was aware, there had been no research on the practices of DFA/FCR in the UK non-life insurance industry, and only two surveys had been carried out several years ago to investigate the practices of DST/FCR in the UK life insurance industry. Therefore, this research was intended to carry out an up-to-date survey on the practices of DFA/DST/FCR across the UK insurance industry. Considering the exploratory nature of enquiry, and taking into account the cost and time required, it was further determined that in the phase of this research the postal survey method was the most appropriate means by which to collect data and gather empirical evidence.

In order to achieve a high response rate the questionnaire used in the postal survey was carefully and deliberately designed to be short and to be easily completed by only ticking boxes provided. Because of the limited pages of the questionnaire, several questions, which might be instrumental in obtaining the general picture of the practices, were not included. Moreover, for some relatively open-ended or complex questions it was not suitable to reduce the number of their possible answers to a few choices because of their nature. Furthermore, following initial analysis of the survey, a number of interesting features arose within the data collected that required further exploration and explanation in order to gain a deeper understanding of the research question. It was therefore decided that conducting interviews with some of the respondents to the postal survey was essential. Several interviews were then carried out and the data collected through the interviews provided an in-depth view of the current practices of DFA/DST/FCR and relevant issues. In addition, conducting interviews also provides an opportunity to triangulate the findings of the survey. We can be relatively confident about the results obtained by employing a combination of methods, called triangulation. The advantages of triangulation can be summarised as follows (Blaikie, 1993):

- To investigate an issue from different perspectives
- To use the strengths of the first method to overcome the deficiencies of the second method
- To reduce the bias resulting from a single-method approach
- To achieve a higher degree of reliability and validity

One of the most important steps in conducting DFA is to determine which risk factors affecting company performance should be included in the DFA/DST project.

To this author's knowledge of the industry practice, in general actuaries are alert to these risk factors based on their understanding of companies' risk exposure and professional judgement. This practice was confirmed at the interviews. The interviewees, who were the Appointed Actuaries and Chief Actuaries for the companies, were asked how their companies investigate their risk profiles, i.e. how their companies identify the material risks affecting company performance. All the interviewees indicated that the identification of the material risk factors of company performance was based on professional judgement.

In general, actuaries are able to correctly identify the risk factors or determinants of company performance simply based on their professional judgement. However, completely relying on the actuary's professional judgement is sometimes too risky because there could be some new or hidden risk factors which cannot be recognised easily. It is always desirable to adopt a positivist approach to help the actuary identify these risk factors. This led to a research initiative, the undertaking of a statistical analysis using an econometric method. The econometric analysis was conducted using industry-wide panel data sets consisting of firm-specific and economic variables. By adopting the econometric approach it was possible to identify the determinants of company performance of the insurance industry.

In this research the econometric method was used to identify the factors that should be carefully considered being included in DFA applications. As to the survey method, among other things it was employed to investigate which risk factors were included in the scenarios by the respondents and how they rated the possible performance determinants listed. The econometric results that are supposed to be relatively objective were then compared with the survey results that are mainly based on professional judgement. The main purpose of this comparison between these two is to investigate whether professional judgement is sound. The comparison of the results will be presented in Section 8.7 of Chapter eight. A number of pieces of advice will be also provided based on the findings of the comparison.

It is worth noting that whether professional judgement is sound has knock-on effects concerning the use of scenario and simulation modelling. Generally speaking, it seems that there is no great need for simulation studies if professional judgement is sound. In this case, scenario modelling and stress testing seem to serve. This is because the scenarios for scenario modelling are limited to the actuary's preconceived notion about likely future adverse developments of economic and financial conditions. If professional judgement is sound, realistic and possible scenarios can be built and the ability of an insurance company to withstand changes in both the external environment and the particular experience of the company can be accordingly assessed. In general professional judgement is required in scenario testing more than in stochastic simulation since the number of scenarios built for scenario testing is far less than the number of scenarios generated stochastically for simulation studies. It should be noted that professional judgement is still indispensable when conducting stochastic simulation. Without sound professional judgement, the probability distributions assumed for the variables may be doubtful.

This thesis will present the findings of this research design and contribution to knowledge in this field. The next section will consider each of the research methods utilised.

5.3 Research Method

5.3.1 The Survey Method

As stated previously, the survey method was regarded as the most appropriate means by which to gather data because of the type of the first two research questions. It was decided that at the stage of this research a postal survey was preferable to a series of interviews for the reasons listed below. First, this part of the research was intended to gather the raw data, which aimed to serve as an overview of the current practices of DFA/DST/FCR in the UK insurance industry. In order to get a general picture of the practices, a large-scale postal survey was more appropriate than a usually relatively small-scale interview programme. Second, the cost of the administration of a postal survey was relatively small in terms of money and time.

Third, at the stage of this research the chance of gaining access to the Appointed Actuary, Chief Actuary or Finance Director within the organisation for a possible interview was considered to be low. Therefore, it was decided to administer a postal survey instead of conducting a series of interviews at this stage of research.

As a researcher, it is important to know the advantages and disadvantages of each research utilised. Gillham (2000) summarises the pros and cons of questionnaires, and some of them are listed as follows:

Pros of questionnaires:

- Low cost in time and money.
- Easy to get information from many people very quickly.
- Respondents can complete the questionnaire when it suits them.
- Respondents' anonymity.

Cons of questionnaires:

- Problems of data quality in terms of completeness and accuracy.
- Typically low response rate.
- Misunderstanding can not be corrected.

1. The survey population

In this part of the research, there are two survey populations comprising all companies included in the SynThesys Non-Life and Life (Version 3.32) respectively. Because of the availability of the FSA/DTI returns, it was decided to survey the companies included in these two data sets instead of all companies currently authorised to carry on insurance business in the UK. Data such as net admissible assets, profit before tax, net premium written and other accounts of the FSA/DTI returns could be obtained from the data sets, which not only reduced the number of questions but also simplified the questions included in the questionnaire.

There are 346 companies included in the SynThesys Non-Life and 311 companies included in the SynThesys Life respectively. These two data sets consist of the FSA/DTI returns for the period 1985-1999. The stated numbers of insurance companies are the numbers of firms which had ever existed during the period. Newly established insurance companies included in the data sets were also surveyed as long as these companies still existed as of the time the surveys were administered. Apparently if a company ceases to exist in the UK market as of the time the surveys were conducted, it should be excluded. With respect to subsidiary companies which belonged to the same parent group, only the parent company would be surveyed because these subsidiary companies are supposed to have the same practice as their parent company. As a result, the numbers of prospective survey populations were reduced to 131 and 92 for the non-life and life insurance sectors respectively.

It should be noted that the SynThesys Non-Life and Life do not include all the non-life and life insurance companies authorised to carry on insurance business in the UK. However, according to Standard & Poor's Thesys, the producer of SynThesys Non-Life and Life, it has been attempting to cover the largest insurers and to ensure the coverage includes all companies that appeared in any publications. Given that some of the larger insurance companies submit group returns, which include a number of subsidiaries the actual number of companies covered (taking into account these group returns) would be larger than the actual number of the returns included in the SynThesys Non-Life and Life. It is worthwhile to note that the companies included in these two data sets are not necessarily a representative sample of the whole population comprising all the non-life and life insurers authorised to carry on insurance business in the UK. Therefore, it is hazardous to make generalisations about the whole population using the results obtained from the surveys.

2. The survey instrument

The questionnaire used in the survey was intended to gather data from two distinct groups within the populations, those who had access to some form of

DFA/DST/FCR and those who did not. The questions were clearly categorised into three sections under three main headings which were entitled: "Dynamic Financial Analysis" (for non-life insurance companies) or "Dynamic Solvency Testing" (for life insurance companies), "Financial Condition Report", and "The Characteristics of your Company". At the commencement of the first two sections, the respondent was asked whether DFA/DST/FCR were used and then was directed to the appropriate questions which related to the DFA/DST/FCR status of the company.

To be more specific, the questionnaire would confirm whether DFA/DST were being used, how they were used, which risk factors were included, and how assets and liabilities were modelled within the individual organisations. Moreover, the questionnaire would also seek to confirm whether FCR was being produced, whether FCR was available to third parties, whether it is necessary to introduce a Guidance Note on FCR (for non-life insurance companies), and to what extent the GN2 is acceptable (for life insurance companies). Copies of non-life and life questionnaires are presented in Appendix B.

In order to achieve a high response rate considerable attention was given to the design of the questionnaire. First, the questionnaire was designed to be relatively short. It is generally accepted that the length of the questionnaire should be kept as reasonably brief as possible in order to increase the response rate because the increased length adds to the burden on respondents and pushes more of them over a threshold beyond which they will not co-operate (Bogen, 1996). However, for some complicated issues a short questionnaire will produce low response rates because people might consider it too superficial (Dillman, 2000). In fact, the optimal length of a questionnaire will depend on the nature of the recipients and the relevance of the topic to the recipients: the more specialised the recipients and the more relevant the topic, the longer the questionnaire can be (de Vaus, 2002). Considering the above, it was decided to produce a six-page survey document in order to strike a balance between them.

Second, terms and definitions common to the insurance industry were used in the questionnaire to ensure that the recipients were able to clearly understand the questions. Take the section headings of the questionnaire as an example. The first section heading of the questionnaire is "Dynamic Financial Analysis" for non-life insurance companies. For their life counterparts "Dynamic Solvency Testing" rather than "Dynamic Financial Analysis" was used in the questionnaire. The primary reason was that "Dynamic Solvency Testing" is a terminology used in the GN2 which was issued by the Faculty and Institute of Actuaries to help Appointed Actuaries to assess the ability of a life office to withstand internal and external changes. Therefore, Appointed Actuaries, who were the recipients of the questionnaire, are supposed to be familiar with this terminology and know its meaning. Moreover, "Dynamic Solvency Testing" is actually the application of "Dynamic Financial Analysis" for solvency purposes and is one of the forms of "Dynamic Financial Analysis". The main techniques used in "Dynamic Solvency Testing" are sensitivity testing, scenario testing and stochastic simulation, which are the same as those used in "Dynamic Financial Analysis". Therefore, it was decided to use "Dynamic Solvency Testing" in the questionnaire for life insurance companies. In addition, it is worth noting that in the Baird Report the term "Dynamic Solvency Testing" is replaced with "Dynamic Financial Analysis" when GN2 is referred to (The Stationery Office, 2001). That is, in this official report "Dynamic Financial Analysis" and "Dynamic Solvency Testing" are used to mean the same thing.

Third, all the questions in the questionnaire were close-ended and only required to be answered by ticking the boxes which most accurately describe the company. This format of response was intended to reduce the time the respondent has to spend on completing the questionnaire.

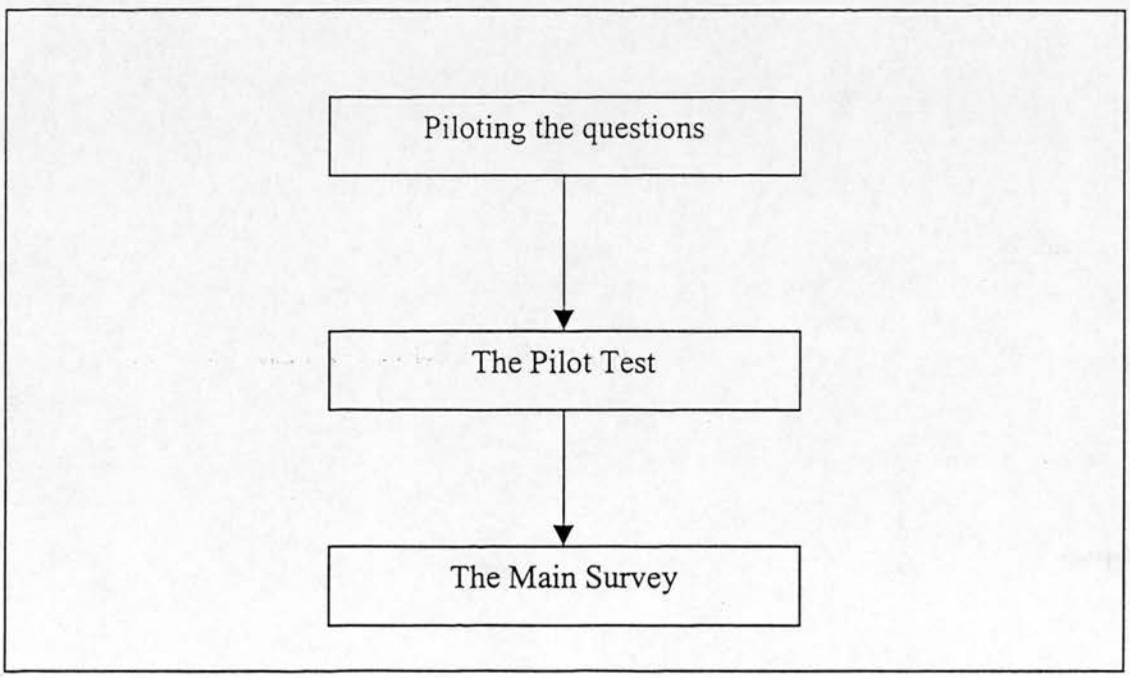
Fourth, the questions were ordered so that the most topical and simplest questions appeared first, while relatively sensitive questions such as company characteristics appeared at the end of the questionnaire.

A covering letter, which briefly outlined the purpose of the survey and contained instructions regarding the completion and return the questionnaire, was posted along with the questionnaire to the prospective respondents (Copies of the covering letters used in the non-life and life surveys are presented in Appendix B). It was emphasised that completing the questionnaire would not take too much time. A preferred returning deadline was also indicated. Moreover, the prospective respondents were requested to complete and return this questionnaire even if their companies did not use any DFA/DST related techniques. Furthermore, the respondents were also advised that if they wished to have an analytical report of the survey findings, they should indicate on their reply and enclose a business card or compliment slip so that the report can be sent. Most importantly the respondents were reassured that all responses would be treated in the strictest confidence.

3. The survey procedure

The survey procedure followed in this part of the research is illustrated in Figure 5.3. Every step of the procedure is discussed in detail as follows:

Figure 5.3: The survey procedure



(1) Piloting the questions

The first step of the survey procedure was piloting the questions. The primary aim of this step is to get the wording right. This step is divided into two stages: first, a list of the prospective questions was tried out with two fellow students who were not specialists in insurance or finance. They were told to see whether or not the wording was clear to them and to indicate possible changes. The objectives of this stage were to ensure that the wording of these questions would be clearly understood and that the use of jargon was reduced to the lowest level possible. The draft was accordingly revised based on the feedback from these non-specialists.

The second stage of piloting the questions was similar to the first one. The only difference was that the revised questions were tried out with two specialists in insurance and finance. They were solicited for suggestions about the content of the questions and answers. The objectives of this stage were to ascertain that the jargon was used correctly and that the answers to the questions were as complete and appropriate as possible. Based on this feedback, some of the questions were removed from the questionnaire and new questions added. In addition, some minor alterations were made to the answers to some of the questions. For instance, the answers to Question nine in both non-life and life surveys were deliberately made slightly different due to the ways of modelling liabilities in the non-life and life sectors. Liabilities are normally aggregated over policies in the non-life insurance sector whereas those are usually modelled by model points or individually (on a policy-by-policy basis) in the life insurance sector.

(2) The pilot test

Two random samples of ten companies each were selected from the survey populations of non-life and life insurance companies for pilot testing the questionnaire respectively. These two pilot tests were administered in April 2002.

In addition to the careful design of the questionnaire designed to achieve a high response rate, it was decided that a named individual should be identified as the recipient. Addressing the questionnaire to a specific recipient is instrumental in increasing the response rate because it personalises the questionnaire and suggests to the prospective respondent that his or her individual response is considered to be important. This individual recipient was sent a questionnaire package consisting of a covering letter, the questionnaire and an addressed pre-paid reply envelope. It was further decided that, in general, the Appointed Actuary or Chief Actuary had the responsibility for conducting DFA/DST/FCR and should be targeted as the survey recipient. However, the identification of the name of the individual within each organisation was a difficult task because not every company has an individual with the designation of Appointed Actuary or Chief Actuary. In the UK, under the current legislation every company transacting long term insurance has an Appointed Actuary with defined responsibilities relevant to the financial condition of the company. However, a statutory requirement for every UK company transacting non-life insurance business to have an Appointed Actuary has not yet been introduced. For most non-life insurance companies, the Chief Actuary or the most senior actuary was targeted as the survey recipient. Nevertheless, some small non-life insurance companies do not even have actuaries within their organisations. In this case, the Finance Director or Chief Financial Officer within the organisation was targeted.

With a view to obtaining the names of the targeted recipients, this author approached a number of official organisations and professional bodies such as the Faculty and Institute of Actuaries, the FSA, the Association of British Insurers, and the Chartered Insurance Institute. All the above organisations or bodies denied the author's access to the names of Appointed Actuaries because either they did not have the data required or under the Data Protection Act they were not able to provide the data. In the end, the names of Appointed Actuaries were identified from the Actuarial Certificate in the FSA/DTI returns. The names of Chief Actuaries, most senior actuaries, Finance Directors or Chief Financial Officers were identified from a range of sources including the Insurance Directory and the Actuarial Directory 2002. Except for the above-mentioned sources, the addresses of the targeted recipients were identified from "Company Names & Address Index" provided by Companies House and "Company List" provided by the Association of British Insurers on their web sites.

The questionnaires were sent by first-class post and the letters were stamped, not franked. A self-addressed stamped envelope was also included in the questionnaire package to minimise the respondent's effort in returning the questionnaire. Both addressing the questionnaire to named individuals and using first-class postage stamps were intended to personalise the surveys and to increase the importance of the surveys in order to achieve a high response rate.

According to the suggestion of Gillham (2000), the questionnaires were deliberately sent on Mondays or Tuesdays in order to ensure that the recipients complete and return the questionnaires when it suits them by the end of that week.

Each targeted recipient chosen for the pilot tests was sent a questionnaire package. Seven days after the preferred returning date indicated in the covering letter (seventeen days after the initial mailing of the pilot test), the non-respondents were sent another questionnaire package. This package was the same as the one sent in the initial mailing except for a revised covering letter. In this revised letter, the recipient was requested assistance in completing the questionnaire if he or she had not already done so. All the postal questionnaires and correspondences can be found in Appendix B.

There were four and nine responses to the non-life and life pilot tests respectively. That is, the response rates for non-life and life pilot tests were 40 per cent and 90 per cent respectively. The distribution of these responses is summarised in Table 5.1.

Table 5.1: Distribution of responses to the pilot tests (Non-life and Life)

Responses to	Non-life pilot test Number of responses (% of total responses)	Life pilot test Number of responses (% of total responses)
Initial mailing	2 (50%)	8 (89%)
Follow-up letter	2 (50%)	1 (11%)
Total	4 (100%)	9 (100%)

The above table shows different patterns of responses to the non-life and life pilot tests. In the non-life pilot test, the responses were achieved equally between the two contacts made to the prospective respondents. However, in the life pilot test, most of the responses were achieved following the initial mailing of the questionnaire.

Respondents were requested to add any comments concerning the questionnaire. After examining the comments provided by the respondents, if any, this author did not find any suggestions directly related to the questionnaire such as wording, instruction, response of categories or type of questions. Thus, it was assumed that the questionnaire was well received by the respondents. No alteration was made to the questionnaire.

(3) The main survey

Following the pilot tests, the main surveys for non-life and life insurance companies were administered in May 2002. The questionnaire package and procedure used in the main surveys were largely the same as those used in the pilot tests. Two exceptions were made. First, the preferred returning date of the questionnaire was removed from the follow-up covering letter. The reason for this is because a number of respondents wishing to complete the questionnaire might be too busy to do so by the indicated preferred returning date. If a preferred returning date was set, these respondents might give up responding to the survey. Second, ten days after the follow-up letter, some of the non-respondents whose email addresses were found in the Actuarial Directory 2002, were emailed to request assistance in completing the questionnaire if they had not already done so.

There were 44 and 62 responses to the non-life and life main surveys respectively. That is, the response rates for the non-life and life main surveys were 36 per cent and 76 per cent respectively. The distribution of these responses to the main surveys is summarised in Table 5.2.

Table 5.2: Distribution of responses to the main surveys (Non-life and Life)

Responses to	Non-life main survey Number of responses (% of total responses)	Life main survey Number of responses (% of total responses)
Initial mailing	33 (75%)	40 (64%)
Follow-up letter	11 (25%)	19 (31%)
Follow-up email	0 (0%)	3 (5%)
Total	44 (100%)	62 (100%)

The above table shows that the majority of the responses were achieved following the initial mailing of the questionnaire. Following the follow-up letter, the responses accounted for around 30 per cent of the total responses received. Although the follow-up email was not an effective method of eliciting responses, it did yield some additional responses.

4. The analysis of the survey data

According to Robson (2002), data analysis can be divided into two broad types: exploratory and confirmatory. The survey data analysis of this thesis is of the nature of both exploration and confirmation. In order to address Questions one and two about the current practices of DFA/DST/FCR, this analysis is aimed for not only exploring the data collected by the means of two postal surveys, but also testing a number of hypotheses to confirm whether they are supported by the data.

The procedure of the analysis of the survey data is as follows: First, data was entered into the Statistical Package for the Social Sciences (SPSS) for analysis. This process of converting responses to numbers is termed as coding. De Vaus (2002) points out that there are six main steps in coding. These steps are:

- Classifying responses
- Allocating codes to each variable
- Allocating column numbers to each variable
- Producing a codebook
- Entering data
- Checking for coding error

Each of the steps was followed in the analysis of the survey data. It is worth noting that the work in classifying responses was done during the questionnaire design phase. A number of responses possibly given by the respondents were listed. This is because the questions in the postal surveys are close-ended. There is no need to classify the responses after data is collected.

A significant proportion of the questions in the surveys allowed the respondent to tick more than one response to a question. Since the multiple dichotomy method was adopted in the analysis, a separate variable should be created for each of the response provided. In total, there are 105 and 109 variables created for the analysis of the non-life and life surveys respectively.

Column numbers were allocated to each variable and a codebook was produced. Then the data was entered with care. Because the scale of the surveys is large, it is necessary to check whether coding errors occurred during the process of manual entry of data into the SPSS. De Vaus (2002) suggests three approaches to checking for coding errors. These are:

- Valid range checks
- Filter checks
- Logical checks

The first two approaches were adopted here, but not the last because it seemed inapplicable in this case. Valid range checks were conducted using simple frequency analysis on each of the variables. The codes outside the valid range were identified and corrected. Filter checks were conducted using contingency questions. For example, the respondent who reported using any of the DFA/DST related techniques should not answer the question about the main reasons for not using them.

Second, the analysis of the data was carried out. As stated previously, the survey data analysis of this thesis is of the nature of both exploration and confirmation. Univariate analysis was conducted to describe the distributions of each of the variables, whereas bivariate analysis to investigate whether two variables are associated.

In addition to the survey data, financial data of the organisations in the two survey populations were obtained from the SynThesys Non-Life and Life to investigate whether non-respondent bias existed. The required data were average net admissible assets, average profit before tax, and average net premiums written (earned) for the years 1996-1999.

5.3.2 The Interview Method

As previously stated, in order to achieve a high response rate the questionnaire was designed to be relatively short and only the most important questions appeared in the questionnaire. As a result, some of the questions unavoidably would not go into too much detail or some minor questions were not even asked because of the limited length of the questionnaire.

Following the completion of the postal surveys and preliminary data analyses, it was found that other research methods should be employed to discover what the postal surveys did not reveal and to clarify the content of some of the questionnaire results. It was then determined that interviews, which are often regarded as a valuable way of triangulating data collected by other means such as a questionnaire, would serve this purpose.

Generally speaking, there are three types of interview: structured interviews, semi-structured interviews, and unstructured interviews. Structured interviews, also known as standardised interviews, use a pre-determined and standardised set of questions. In essence, structured interviews method is actually surveys method, but administered in the form of interview. This type of interview is often used to gather data, which will then be the subject of quantitative analysis (Saunders, Lewis and Thornhill, 2000).

Compared with structured interviews, semi-structured interviews and unstructured interviews are relatively non-standardised. Although semi-structured interviews also use a set of questions, the interviewer in general will not ask the interviewees all the questions and their order may be changed based on individual organisational context. Semi-structured interviews are often used to explain themes that have emerged from postal survey or to clarify the content of survey results (Wass and Wells, 1994). Concerning unstructured interviews, there is no pre-determined question. This type of interview is often used to identify variables whose data will then be collected by questionnaires or structured interviews.

Since the aims of conducting interviews for this research were to triangulate the data collected from the postal survey and to obtain data which was not easily collected via the postal survey, it was determined that semi-structured interviews were the most appropriate means for this purpose.

1. The companies interviewed

In the postal surveys, four non-life and six life respondents indicated in the returned questionnaire that they would be willing to be interviewed as part of this research. The organisations to which these respondents belonged can be classified into three categories relevant to the use of DFA/DST/FCR and company type. These categories and the number of each category are shown in Table 5.3.

Table 5.3: The distribution of the prospective companies for the interview

	Non-life insurer		Life insurer
Dynamic financial analysis / Dynamic solvency testing	√	√	√
Financial condition report	√	×	√
Number of organisations willing to be interviewed	1	3	6
Number of organisations approached	1	3	3
Number of organisations interviewed	1	1	3

In order to have an overall picture of the current practices of DFA/DST/FCR in the insurance industry, it therefore seemed appropriate that the number of organisations approached regarding interview is proportional to that of organisations in each category. It was intended to interview 50 per cent of the organisations in each category. If there was only one organisation in the category, then the organisation was selected. The number of organisation approached for possible interview arrangements in each category is also shown in Table 5.3.

Because most of the organisations were scattered across the country, organisations which were located in the same area were initially targeted in order to reduce the travelling cost and time necessary to conduct the interviews. The locations of the organisations finally approached included Edinburgh, Stirling and London, etc. At each of the seven organisations approached, the staff member (Appointed Actuary, Chief Actuary or Finance Director) who had completed the postal questionnaire was contacted by letter asking whether he or she would be willing to be interviewed as part of the research. A copy of topics for discussion was sent with the letter to each of the prospective interviewees. Copies of the letter and topics for discussion can be found in Appendix C. The aim of posting the copy of topics for discussion was to ensure that the prospective interviewees understood the topics which would be discussed at the interview and had time to prepare before the interview if they were willing to do so. About ten days after the letters were posted, the prospective interviewees were contacted by telephone to arrange a mutually convenient time for a meeting.

Of the six prospective interviewees who were initially approached, four agreed to be interviewed. The remaining two were not available due to other commitments. As a result, another respondent in the same category as the two unavailable was identified. The letter and the copy of topics for discussion were immediately emailed to the newly identified prospective interviewee. In the meantime, the letter and the copy of topics for discussion were also posted. Three days later, the prospective interviewee was contacted by telephone. The interviewee candidate kindly agreed to be interviewed. Therefore five face to face semi-structured interviews, in total, were conducted. All the interviews were conducted in July 2002.

2. The interview instrument

As stated previously, the interview format was semi-structured. Thus, it was necessary to develop the topics for discussion at the interview. Due to the type of insurer and the status of the use of DFA/DST/FCR, three versions of topics for discussion were developed. The copy of these topics for discussion served as a checklist. These interviews were seeking to elicit a range of factual information about the current practices of DFA/DST/FCR within individual organisations in order to enrich the results obtained from the postal surveys.

3. The interview procedure

The following procedure of interview was followed:

(1) Greetings and thanks:
The interviewee was greeted and thanked for participating in the postal survey and agreeing to the meeting.

(2) The purpose of the research and the research progress to date
The purpose of the research and the research progress to date were briefly presented to the interviewee.

(3) Confidentiality and anonymity

The interviewee was assured that all the information provided would be treated in the strictest confidence and the name of the organisation would not be identified in the research report.

(4) Permission to tape-record the interview

The interviewee was requested permission to tape-record the interview. Before permission was sought, two main reasons why tape-recording was considered necessary in addition to note taking were explained to the interviewee. First, tape-recording makes accurate and unbiased record possible. Second, this record may serve as future reference and can be re-listened where necessary.

(5) Topics for discussion

The interviewee was given another copy of topics for discussion, which was the same as the one posted to her or him. In the meantime, the interviewee was told that the discussion would not necessarily be confined to these topics and other topics might be brought into the conversation where appropriate.

(6) Permission to start the interview

The interviewee was requested permission to start the interview.

(7) Thanks

The interviewee was thanked for her or his time, participating in the interview process and contribution to the research.

In general, all face-to-face interviews were conducted smoothly. In order to maintain concentration and focus both tape-recording and note making were done at the same time during the interview.

4. The analysis of interview data

Since the interviews conducted were semi-structured, most of the data obtained was qualitative rather than quantitative. Therefore, the process of analysis of the interview data was mainly based on one of the most commonly used set of procedures for qualitative research, often referred to as "grounded theorising" (Sapsford and Jupp, 1996). The first step of the grounded theorising was data preparation. The tapes were transcribed soon after the interviews in order to grasp the important points provided by the interviewees when the memory was still fresh. Follow-ups were made through phone calls and emails to clarify the interview transcripts. Judgement had to be, inevitably, exercised to determine what needs to be included in the transcripts. The exercise of judgement was based on the relevance of the material. Those which were not related to the topics and were not instrumental in understanding the practices of DFA/DST/FCR, were excluded from the transcripts.

The second step was a close reading of the transcripts. Then colour-coding technique was employed with a view to identifying key points in the interview data. The basic principles of colour coding are largely the same as those of computer software for code-based analysis such as Nudist and NVivo. The themes were coded and were highlighted using pens of different colour. In this analysis, using computer software for code-based analysis was not deemed necessary due to the small number of interview transcripts.

The next step was to gather together the identified key points that were then assigned under a number of headings of topics and themes. Most of the topics and themes were pre-specified. However, new topics or themes were set for some identified key points as long as they were relevant to the current practices in question.

The final step was to compare and contrast all the identified key points which had been assigned under the same heading of topics and themes. The aim of this step was to investigate the similarities and differences among the organisations interviewed.

5.3.3 The Econometric Method

In general actuaries mainly use their own professional judgement when determining which risk factors should be tested or assumptions should be varied in DFA/DST. This was also the current practice in all the organisations interviewed. In this thesis, it was intended to use econometric techniques to help actuaries to identify the determinants of company performance. These determinants can be regarded as important risk factors or assumptions which should be varied in DFA/DST. The purpose of this section is to provide an overview of the approach taken in the econometric analysis.

The econometric techniques used in the thesis are panel data models. Panel data, also known as longitudinal or temporal cross-sectional data, are obtained by following a cross-section of individual units over several periods of time. It involves the pooling of time series and cross-sectional data. Because of the pooling of the data of the two dimensions, time series and cross-sectional dimensions, panel data has special advantages over time series or cross-sectional data alone.

The main advantage of panel data as compared to a pure time series or cross-sectional data is that it allows us to control temporally persistent differences among individuals or companies that in many instances may bias estimates obtained from cross-sections (Maddala, 1993). Panel data is in a good position to identify the effects that are difficult or unable to be discerned in pure time series or cross-sectional data. This is also the primary reason why this research is conducted using panel data. Other advantages or benefits of using panel data include reducing the collinearity among explanatory variables, controlling for individual heterogeneity and testing more complicated behavioural models. Inevitably, panel data have some limitations, such as data collection and selectivity problems (Hsiao, 1986; Baltagi, 1995).

The rest of this section is organised as follows: First, the reasons why the statutory FSA/DTI returns instead of the Company Act accounts are used in the empirical analyses of Chapter eight will be discussed. Second, the reasons why a particular data set is selected are also discussed. Third, the alternative linear models for panel data and related issues are presented.

1. Why FSA/DTI returns are used

What kind of data used in the research depends on what kind of question the researcher would like to address. That is, the research question should serve as the best guide to appropriate data sources. In order to address the third and fourth research questions of the thesis about the determinants of insurance company performance, the data required is supposed to be reliable, comparable, and longitudinal.

After approaching a variety of data sources, this author found that two kinds of data may meet the criteria stated above. One is the statutory returns and the other the Companies Act accounts. These statutory returns are called the FSA/DTI returns in this thesis because they are the returns filed by UK insurance companies to the insurance supervisory authority, which used to be the Department of Trade and Industry (DTI) but is now the Financial Services Authority (FSA). In addition, UK insurance companies are also required to file annual statements of accounts under the Companies Act 1985, which governs the conduct of all commercial companies in the UK. These accounts stated on the annual financial statements are referred to as the Companies Act accounts.

The data used in the empirical analyses of this research is the FSA/DTI returns. There are three reasons why the FSA/DTI returns are preferable to the Companies Act accounts for the research of this thesis. First, the FSA/DTI returns are more detailed and comprehensive than the Companies Act accounts. In many cases, insurance companies are asked to provide data in the FSA/DTI returns for individual lines of business. Second, the FSA/DTI returns are provided based on prescribed and standardised formats but the Companies Act accounts are not. Prescribed and standardised formats are consistent in presentation and permit very little flexibility in how companies report their returns, unlike their annual Companies Act accounts. As a result, the formats can facilitate the comparisons among companies. In contrast, every company uses different formats in producing its own financial statements for the Company Act accounts. Different names of accounts appear in financial statements of different companies, even though they could indicate the exactly same thing. Likewise, the accounts with the same names could mean slightly different things. Therefore, it is difficult to extract for research purposes the required accounts from the financial statements prepared by insurance companies in accordance with the Companies Act 1985 without knowing the definitions of accounts in each company. Finally, the FSA/DTI returns have the advantage of wider market coverage, which include some non-public stock and mutual insurance companies.

2. Why the SynThesys Non-Life and Life data sets are used

After the decision to use the FSA/DTI returns as the data for the empirical analyses was made, the next step is how to find and procure the data. Many different possible data sources were approached and three were identified in the end. These were Companies House, A. M. Best, and Standard & Poor's Thesys. After comparing the data sets provided by these three organisations based on the criteria of cost, coverage, consistency and comparability, the SynThesys Non-Life and Life produced by Standard & Poor's Thesys were chosen as the data sets used in the empirical analyses.

As stated previously, the SynThesys Non-Life and Life consist of the FSA/DTI returns for 346 non-life and 311 life insurance companies for the period 1985-1999. The names of the companies included in these two data sets can be found in the appendices of the user guides (Standard & Poor's Thesys, 2001a; 2001b). Insurance companies filed statutory returns based on the formats prescribed in the relevant regulations. During the period 1985-1999, there were two regulations under which the formats of statutory returns were prescribed. These were the Insurance Companies (Accounts and Statements) Regulations 1996, which came into force on 23 December 1996 and the Insurance Companies (Accounts and Statements) Regulations 1983. It should be noted that the formats of the Forms of statutory returns prescribed in the above-mentioned two Regulations are, inevitably, different.

Based on the Insurance Companies (Accounts and Statements) Regulations 1996, Standard & Poor's Thesys reconstructed the data by detailed comparison of statutory returns from 1985 through 1995 produced under the Insurance Companies (Accounts and Statements) Regulations 1983. The combination of data from both 1983 and 1996 Regulation formats enables company performance from 1985 onwards to be analysed on a comparable and consistent basis.

3. The alternative linear models for panel data

The general form of a regression model of panel data is as follows (Judge et al., 1980):

$$y_{it} = \alpha_{it} + \sum_{k=1}^{K} \beta_{kit} x_{kit} + \varepsilon_{it} \qquad (5.3.1)$$

where

y_{it} is the value of the dependent variable for individual unit i at time t.

x_{kit} is the value of the kth explanatory variable for individual unit i at time t.

k is the index of explanatory variables and k= 1, …., K.

i is the index of individual units and i= 1, …., N.

t is the index of time periods and t= 1, …., T.

α_{it} and β_{kit} are coefficients or parameters to be estimated.

ε_{it} is the error component for individual unit i at time t and is assumed to have mean zero, $E[\varepsilon_{it}]=0$ and constant variance $E[\varepsilon_{it}^2]= \sigma_\varepsilon^2$.

This general form (5.3.1) can be extended to a more complicated one with more subscripts (dimensions). For instance, Resmini (2000) considers factors affecting the pattern of foreign direct investment at sector level in twelve host countries in Eastern Europe over the period 1990-1995. Therefore, there are three kinds of subscripts on the dependant variable of the estimated regression model, sector, country and period of time.

For simplicity reasons, (5.3.1) can be expressed in terms of matrix as follows:

$$y_{it} = \alpha_{it} + \beta' x + \varepsilon_{it} \qquad (5.3.2)$$

where

$\beta' = (\beta_{1it}, \beta_{2it}, \ldots, \beta_{Kit})$

$x' = (x_{1it}, x_{2it}, \ldots, x_{Kit})$

ε_{it} is a classical disturbance with $E[\varepsilon_{it}] = 0$ and $Var[\varepsilon_{it}] = \sigma_{\varepsilon}^2$.

Based on the general form of the linear model for panel data, there are different classification methods depending on whether the coefficients are assumed to be fixed or random, and on whether time effects as well as individual unit effects are taken into account. Time effects are typically modelled as specific to the period in which they occur and are not carried across time periods within a cross-sectional individual unit. Individual unit effects are modelled as being specific to the individual cross-sectional units and are carried across time periods within a cross-sectional individual unit (Greene, 2000).

For instance, Judge et al. (1980) classify the linear models for combining time series and cross-sectional data into five main categories[1].

---

[1] As stated previously, there are different methods of classifying the linear models for panel data. Baltagi (1995, Chapter three and four) only focuses on category 2 and 3 and calls them one-way error component regression model and two-way error component regression model respectively depending on whether time effects are taken into consideration. In the one-way error component regression model, only individual unit effects are considered, whereas both time effects and individual unit effects are taken into account in the two-way error component regression model.
In general, the model can be expressed as follows:

$$y_{it} = \alpha + \sum_{k=1}^{K} \beta_k x_{kit} + \varepsilon_{it}$$

In the one-way error component regression model, the error component, ε_{it} is decomposed into two parts, μ_i and φ_{it}; in two-way error component regression model, the above-mentioned error component is decomposed into three parts, μ_i, v_t and φ_{it}. μ_i are individual unit effects and are time-invariant; v_t are time effects and are invariant across all individual units; φ_{it} is random error term and is independently and identically distributed $(0, \sigma^2_{\varphi})$. Then both one-way and two-way error component regression models can be further classified into fixed and random effects models depending on whether the coefficients are fixed or random.
In this thesis, the basic structure of classification of Judge et al. (1980) is adopted. However, based on the work of other academics (See, for example, Baltagi (1995), and Greene (1998; 2000)) some

Category 1: All coefficients are assumed to be constant.

$$y_{it} = \alpha + \sum_{k=1}^{K} \beta_k x_{kit} + \varepsilon_{it} \tag{5.3.3}$$

Category 2: Intercept terms vary across individual units, but slope coefficients are assumed to be constant.

$$y_{it} = \alpha_i + \sum_{k=1}^{K} \beta_k x_{kit} + \varepsilon_{it} \tag{5.3.4}$$

It is assumed that the difference in behaviour among individual units can be captured by the varied intercept terms. This model can be rewritten as follows:

$$y_{it} = \bar{a} + \mu_i + \sum_{k=1}^{K} \beta_k x_{kit} + \varepsilon_{it} \tag{5.3.5}$$

where

$\bar{a}$ is the mean intercept.

μ_i are the deviations from the mean intercept for the *i*-th individual units and are time-invariant. μ_i are referred to as individual unit effects.

Category 2-1: μ_i are assumed to be fixed coefficients for each individual units.

In this subcategory, intercept terms vary over individual units, i.e. different individual units have their own intercept terms. The intercept terms are fixed and are invariant across time periods. This type of model is called one-way fixed-effects model[2].

---

changes in nomenclature will be made to the classification by Judge et al. (1980) in order to make the names of the models more understandable and clear.

[2] This type of model is referred to as dummy variable model in Judge et al. (1980) or least squares dummy variable model in Greene (2000) since dummy variables can be used to rewrite this model.

Category 2-2: μ_i are assumed to be random for each individual units.

In this subcategory, μ_i are assumed not only to vary across individual units but also to be random variables with mean zero, $E[\mu_i]=0$ and constant variance $E[\mu_i^2]= \sigma_\mu^2$. The μ_i and ε_{it} are also assumed to be uncorrelated. This type of model is called one-way random-effects model[3].

Category 3: Intercept term varies across individual units and across time periods, but slope coefficients are assumed to be constant.

$$y_{it} = \alpha_{it} + \sum_{k=1}^{K} \beta_k x_{kit} + \varepsilon_{it} \tag{5.3.6}$$

It is assumed that the difference in behaviour among individual units and different time periods can be captured by the varied intercept terms. This model can be rewritten as follows:

$$y_{it} = \bar{a} + \mu_i + r_t + \sum_{k=1}^{K} \beta_k x_{kit} + \varepsilon_{it} \tag{5.3.7}$$

where

r_t are also the deviations from the mean intercept for the *tth* time periods and are applied to all individual units during that time period[4]. r_t are referred to as time effects.

Category 3-1: Both μ_i and r_t are assumed to be fixed coefficients.

In this subcategory, intercept terms vary across individual units and across time periods. That is, both individual unit effects and time effects are taken into

[3] This type of model is referred to as random error components model in Judge et al. (1980).

[4] That is, r_t are invariant across all individual units during time period t.

accounts in this model. Moreover, it is assumed that these effects are fixed. This type of model is called two-way fixed-effects model[5].

Category 3-2: Both μ_i and r_t are assumed to be random.

In this subcategory, intercept terms also vary across individual units and across time periods. μ_i and r_t are assumed to be random variables. Both of them have mean zero, $E[\mu_i]=0$ and $E[r_t]=0$, and have constant variance, $E[\mu_i^2]= \sigma_\mu^2$ and $E[r_t^2]= \sigma_r^2$. The μ_i and r_t and ε_{it} are also assumed to be uncorrelated. This type of model is called two-way random effects model[6].

Category 4: All coefficients are assumed to vary across individual units.

$$y_{it} = \sum_{k=0}^{K} \beta_{ki} x_{kit} + \varepsilon_{it} \tag{5.3.8}$$

where

x_{0it} is defined as 1. Thus, β_{0i} is similar to the intercept term in the previous formulas.

It is assumed that the response of the dependent variable y_{it} to an explanatory variable x_{kit} is different for different individual units but, for a given individual unit, it is constant over time. That is, coefficients only vary over individual units.

Category 4-1: β_{ki} are assumed to be fixed coefficients.

This type of model is referred to as seemingly unrelated regression model.

Category 4-2: β_{ki} are assumed to be random coefficients.

This type of model is referred to as Swamy random coefficient model.

---

[5] This type of model is also referred to as dummy variable model in Judge et al. (1980).

[6] This type of model is also referred to as random error components model in Judge et al. (1980).

Category 5: All coefficients vary across individual units and across time periods.

$$y_{it} = \sum_{k=0}^{K} \left(\bar{e}_k + \mu_{ki} + r_{kt} \right) x_{kit} + \varepsilon_{it} \tag{5.3.9}$$

where

the sum of $\bar{e}_k$, μ_{ki} and r_{kt} measures the response of the dependent variable to the kth explanatory variable for individual unit i during the time period t. Each coefficient include a mean $\bar{e}_k$, an individual unit effect varying across individual units and a time effect varying across time periods.

3. Choice among alternative models

The alternative linear models mentioned previously have common general form and have gradually increasing complexity. One model is usually a special case of another. In this case likelihood ratio (LR) test can be used between two models to test which model is more appropriate than the other one (Klugman, 1998). This test can be described as follows:

Null hypothesis: The simpler model is appropriate.

Alternative hypothesis: The more complex model is appropriate.

The LR test statistic is twice the difference of the logarithm of the likelihoods of the two models and can be stated as follows:

$$LR = 2(\log L_2 - \log L_1) \tag{5.3.10}$$

where

L_1 and L_2 are the likelihoods of the simpler and more complex models respectively.

Under the null hypothesis, LR is distributed as chi-squared distribution with degree of freedom k, which is the difference in the number of parameters of the two models.

Decision rule: If the LR test statistic is greater than critical chi-squared value, then the null hypothesis that the simpler model is appropriate is rejected. That is, large value of LR test statistic argues in favour of the more complex model.

4. Choice between fixed-effects and random-effects models

Since fixed-effects and random-effects models are two types of models most frequently used by applied researchers for panel data analysis, the following discussion will be focused on how to choose between the two models.

(1) Important issues

It is one of the difficult decisions for applied researchers to choose between fixed-effects and random-effects models for their empirical work. It has been suggested in the literature that several issues on the choice between the above-mentioned two models are worth considering. See, for example, Judge et al. (1980), Balestra (1996), Pindyck et al. (1998), Wooldridge (2000) and Greene (2000).

a. The nature of sample and inference

The fixed-effects model is considered to be appropriate when the sample is exhaustive[7] and the researcher only intends to make inference with respect to characteristics of the individual units in the sample. In contrast, the random-effects model is believed to be more appealing if the sample is drawn from a large population and the researcher intends to extend his or her inference with respect to characteristics of the sampled individual units to the whole population in question.

b. Assumption of the relationship between individual unit effects and the explanatory variables.

---

[7] That is, the whole population has been completely or nearly completely sampled.

For the random-effects model, it is assumed that the individual unit effects are uncorrelated with the explanatory variables. On the other hand, the fixed-effects model does not require the above-mentioned assumption. Therefore, if the researcher is sure that there is no correlation between explanatory variables and individual unit effects, the random-effects model is believed to be more appropriate than the fixed-effects model.

c. The underlying causes of individual unit effects

If individual unit effects are considered to be related to a large number of unobservable random effects, the random-effects model is preferable instead of fixed-effects model.

(2) Statistical tests

The above-mentioned issues on the choice between fixed-effects and random-effects model are only general principles. Breusch and Pagan (1980) and Hausman (1978) propose two statistical specification tests (Baltagi, 1995; Greene, 1998):

a. Specification test by Breusch and Pagan (1980)

Simply speaking, the specification test by Breusch and Pagan is the test of a homoscedastic and nonautocorrelated classical regression model against panel data models, including fixed-effects and random-effects models. The Lagrange Multiplier (LM) test statistic is calculated using the ordinary least squares residuals from the classical regression model.

Null hypothesis: The classical regression model is appropriate.

Alternative hypothesis: The fixed-effects model or random-effects model is appropriate.

The LM test statistic is calculated as follows (Greene, 1998):

$$LM = \frac{NT}{2(T-1)}\left[\frac{\sum_{i=1}^{N}\left(\sum_{t=1}^{T} e_{it}\right)^2}{\sum_{i=1}^{N}\sum_{t=1}^{T} e_{it}^{\;2}} - 1\right]^2 \tag{5.3.11}$$

where

e_{it} are the ordinary least squares residuals from the classical regression model

Under the null hypothesis, LM is asymptotically distributed as $\chi_{(1)}^{\;2}$ for one-factor model and $\chi_{(2)}^{\;2}$ for two-factor model.

Decision rule: If the LM test statistic is greater than critical chi-squared value, then the null hypothesis that the classical regression model is appropriate is rejected. That is, a large value for LM test statistic argues in favour of fixed-effects or random-effects model.

b. Specification test by Hausman (1978)

Simply speaking, the specification test by Hausman is the test of the random-effects model against the fixed-effects model.

Null hypothesis: The random-effects model is appropriate (i.e. the preferred estimator is generalised least squares estimator). Or there is no correlation between the effects and the explanatory variables.

Alternative hypothesis: The fixed-effects model is appropriate (i.e. the preferred estimator is least squares with dummy variables estimator). Or there is some correlation between the effects and the explanatory variables.

The Hausman test statistic is calculated as follows (Greene, 1998):

$$H = \left(\hat{h}_{gls} - b_{lsdv}\right)' \left\{Var\left[b_{lsdv}\right] - Var\left[\hat{h}_{gls}\right]\right\}^{-1} \left(\hat{h}_{gls} - b_{lsdv}\right) \tag{5.3.12}$$

where

$_{gls}$ is the vector of the slopes in generalised least squares model.

b_{lsdv} is the vector of the slopes in least squares dummy variable model.

Under the null hypothesis, the Hausman test statistic is asymptotically distributed as $\chi_{(k)}^2$ and k is the number of explanatory variables (the degree of freedom).

Decision rule: If the Hausman test statistic is greater than the critical chi-squared value, then the null hypothesis that the random-effects model is appropriate is rejected. That is, a large value for Hausman test statistic argues in favour of fixed-effects model.

5.4 Summary and Conclusions

This chapter has described and justified the research design which underpins the empirical analyses whose findings will be reported in the next three chapters of this thesis. In order to conduct the research with necessary rigour, the positivist paradigm and quantitative methodology are adopted in most aspects of the research. Nevertheless, on some occasions it is indispensable to adopt an interpretative paradigm and qualitative methodology with a view to obtaining a complete picture of the research questions.

Due to the nature of the research questions, three research methods are employed in this thesis. These are survey, interview, and econometric methods. The mixed research methods make the investigation of the four DFA related questions possible.

In order to investigate the current practices of DFA/DST/FCR in the insurance industry, two postal surveys were administered. Semi-structured interviews with five survey respondents were also conducted.

Finally, the econometric method was employed to identify the determinants of insurance company performance based on two panel data sets. A number of relevant hypotheses were tested to determine the direction of the relationship between performance and both economic and firm-specific factors.

Chapter Six

The Current Practices of Dynamic Financial Analysis: Survey Evidence

6.1 Introduction

This chapter reports the findings of the two postal surveys which provide empirical evidence on the current practices of Dynamic Financial Analysis (DFA) / Dynamic Solvency Testing (DST) / Financial Condition Reporting (FCR) in the UK insurance industry. In particular, this chapter will provide evidence on the extent to which insurance companies use DFA/DST related techniques, how they use the techniques and some relevant issues regarding FCR.

It is important to reiterate at the outset of this chapter that the generalisation of the survey results should be always treated with caution. As previously mentioned, the populations of the non-life and life surveys are based on the 346 and 311 companies included in the SynThesys Non-Life and Life (Version 3.32) respectively. The stated numbers of companies are the numbers of insurers which had ever existed during 1985-1999. If a company ceases to exist in the UK market as of the time the surveys were administered, it should be excluded. With respect to subsidiary companies, only the parent company would be surveyed. Accordingly the numbers of the survey populations were reduced to 131 and 92 for the non-life and life sectors respectively. Since the populations of the two surveys were the companies included in the two SynThesys data sets except those excluded based on the criteria mentioned above and all the insurers in these populations were surveyed, it is safe to draw conclusions about the populations from the results obtained. Nonetheless, it is hazardous to generalise the results to a larger population such as all companies currently authorised to carry on insurance business in the UK.

As reported in the previous chapter, the response rates for the non-life and life main surveys were 36 per cent and 76 per cent respectively; forty four (non-life) and 62 (life) responses were obtained. As shown below, there were 34 (non-life) and 58 (life) usable responses respectively. Since not all of the responding insurers reported employing DFA/DST techniques and most of the data analyses conducted in this chapter only focused on the companies reporting using these techniques, the problem of "small samples" might arise in some cases. Moreover, because the distributions of the populations might be non-normally distributed, non-parametric statistics or significance tests were in general used in these analyses. The results concerning the use of these statistics or tests in the context of small samples should be treated with caution.

In the case of a bivariate analysis, cross tabulation is a common way of representing how categories of one variable are distributed across the categories of another variable. A Chi-square test is usually employed for crosstabulation significance. It should be noted that the Chi-square measure is sensitive to sample size and departures from multivariate normality of the observed variables. In general, Chi-square procedures can be legitimately applied only if the data must be random samples from multivariate normal distribution and all expected values (frequencies) in each cell must not be too small. As a rule of thumb, the expected values must be equal to or greater than five for the Chi-square test to be meaningful. If the total sample size and the expected values are small, the Fisher's exact test is a useful alternative to Chi-square for the special case of two by two tables.

In the case of a small sample with a crosstabulation that is more than two by two, it is recommended that the data be meaningfully collapsed to two by two. If this cannot be done properly, only the univariate analysis is conducted. In this case, we simply do not have the data necessary to examine the relationship between variables in which we are interested.

It is worthwhile to mention that the p-values associated with Chi-square and the Fisher's exact probability are significant measures that indicate how likely the relationship in the population differs from zero. The p-values associated with the Phi coefficients and Cramer's V (size measures), which are in fact transformations of Chi-square, are the p-values associated with Chi-square that is built into these statistics. Therefore, these p-values are significance measures, but are only valid if we have adequate sample size to use Chi-square validly. Due to the possible "small samples" problem, the Chi-square statistic, Phi coefficient, Cramer's V and their associated p-values will not be employed in this chapter.

Besides, since the use of correlation is frequently seen in this chapter, it is also important to note at the outset that proving a correlation is not the same thing as proving a cause-and-effect relationship. For example, A may be correlated to B, but this does not mean that A causes B. Some rigorous sampling and statistical techniques should be used to eliminate all other possible factors before a causal relationship can be established. Moreover, a reasonable mechanism to account for the cause-and-effect relationship should be proposed.

Although the survey method was regarded as the most appropriate means by which to investigate the current practices of DFA/DST/FCR, it still has its limitations, as described in Section 5.3.2. It was then considered essential to conduct interviews to have more in-depth understanding of this issue. Therefore, the next phase of the research will place great emphasis on discovering what the postal surveys did not reveal and clarifying the content of some of the questionnaire results using the interview method.

The layout of this chapter is as follows. The following section presents the survey evidence on the current DFA/FCR practices in the non-life insurance sector. In addition to the analysis of the data of the non-life insurance industry as a whole, a number of analyses by different forms of insurance offered are also carried out where appropriate.

The results are also reported and discussed in this section. Similarly, Section 6.3 not only reports the survey evidence on the current DST/FCR practices in the life sector as a whole, but also investigates the similarities and differences between with-profit and non-profit offices. Moreover, the comparison and contrast between the practices of general insurers and those of life offices are also made and discussed. In order to draw the comparison, it is unavoidable in this section to repeat a number of statistical tests that have been conducted in the previous section. In the final section, the key findings of the surveys are summarised.

6.2 The Current Practice of the Non-Life Insurance Industry

6.2.1 The Main Survey

The non-life survey population is based on the companies included in SynThesys Non-Life. The number of the non-life population surveyed is 131. Ten organisations were surveyed in the pilot test. The remaining 121 organisations were contacted in the main survey. Of the 121 organisations, 44 responses were received, representing a response rate of 36 per cent. Nonetheless, ten of these responses were in the form of a letter or an email, explaining why the questionnaire was not completed. Of the ten, four stated that their organisations were in run-off and closed to new business. Three stated that it was not the company's policy to complete questionnaires of any description. One stated that the company does not appear to fall within the scope of the questionnaire and one stated that he was unable to complete the questionnaire due to pressure of work. The other one indicated that the company has sold its non-life insurance business to another company and accordingly the questionnaire appeared irrelevant to the company's existing business. This produced an overall total of 34 usable responses from a population of 121, giving a usable response rate of 28 per cent. A number of the respondents commented on the questionnaires and provided useful information on the current practices of DFA/FCR in the industry.

6.2.2 The Non-Respondent Bias

The non-respondent bias, also known as the non-return bias, could exist in not only the sampled survey but also complete survey. The bias stems from the fact that the returned questionnaires are not necessarily evenly distributed throughout the sample or the whole population. If this bias does exist, the statistical inference regarding the survey would be problematic. Therefore, it is essential to conduct a test for non-respondent bias before the analysis of the data which was collected from the postal survey.

In order to conduct the non-respondent bias test, three financial characteristics were selected to determine whether or not there are any significant differences between the non-respondents and respondents. The three financial characteristics chosen were average net admissible assets, average profit before tax and average net premiums written. These required data were obtained from the SynThesys Non-Life for the years 1996-1999.

An independent-samples t test was conducted to test whether or not the non-respondent bias exists. Before the independent-samples t test was conducted, it was necessary to determine whether or not the respondent and non-respondent groups have equal variances. Thus, Levene's test for equality of variances was carried out for the above-mentioned financial characteristics using a α level of 0.05. The statistical results are shown in Table 6.1.

Table 6.1: Levene's test for the financial characteristics (Non-Life)

Financial characteristic	F	P-value	Decision (α=0.05)
Average net admissible assets	4.601	0.034	Reject H_o
Average profit before tax	0.283	0.596	H_o cannot be rejected
Average net premiums written	0.000	1.000	H_o cannot be rejected

The null hypothesis of the Levene's test is that the financial characteristics of the respondent and non-respondent groups have equal variances. The above table shows that the null hypothesis is rejected for the average net admissible assets, but cannot be rejected for the average profit before tax and average net premiums written. Thus, it was assumed that these two groups do not have equal variances in terms of the average net admissible assets. However, it was assumed that these two groups have equal variances in terms of the average profit before tax and average net premiums written.

Based on these assumptions regarding variances, independent-samples two-tailed t tests were conducted for these three financial characteristics. The null hypotheses were that the means of the net admissible assets, profit before tax and net premiums written of the survey respondents were equal to those of the survey non-respondents. The results are shown in Table 6.2.

Table 6.2: Independent-samples t test for the non-respondent bias (Non-Life)

Financial characteristic	Survey respondent (£000)	Survey non-respondent (£000)	t (p-value)	Decision (α=0.05)
Average net admissible assets	52,032	115,140	–1.543 (0.126)	H_0 cannot be rejected
Average profit before tax	19,675	24,980	–0.250 (0.803)	H_0 cannot be rejected
Average net premiums written	104,070	110,173	–0.092 (0.927)	H_0 cannot be rejected

The above table shows that the null hypotheses cannot be rejected for average net admissible assets, average profit before tax and average net premiums written at the 0.05 level. This suggests that the survey respondents are broadly representative of the survey population in terms of these financial characteristics.

It is worthwhile to point out that one of the assumptions behind an independent-samples t test is the homogeneity of variances of the respondent and non-respondent groups. As previously reported, the null hypothesis of the Levene's test is rejected for the average net admissible assets. That is, these two groups do not have equal variances in terms of average net admissible assets. It means that these two groups differ in this regard. Nevertheless, when there are unequal group variances, a number of methods of separate variance estimates can be used to compensate for the lack of homogeneity. One of the methods is called the Welch method. This method is implemented by most computer packages for statistical analysis including the SPSS which is the software used to analyse the survey data. Although these two groups differ due to unequal variances, it does not mean that one cannot continue to conduct the independent-samples t test. In this case, as mentioned previously, some method should be used to compensate for the lack of homogeneity of variances. In this thesis the problem is dealt with using the SPSS which employs the Welch method. After dealing with this problem, we can continue to conduct the independent-samples t test.

6.2.3 Survey Results

This section presents a factual account of the findings of the postal survey of the current DFA/FCR practices in the non-life insurance sector. To this author's knowledge, there is no similar UK research which can be fully compared with these findings. The only partly comparable survey is the one conducted by Oakden, Friedland and Périgny (2001) to collect information on Appointed Actuaries' approach to Dynamic Capital Adequacy Testing (DCAT) analysis and reporting. They invited 36 the largest Canadian property and casualty insurance and reinsurance companies to participate in the survey and 22 responded. The findings of the non-life survey are compared with those of Oakden, Friedland and Périgny (2001) where appropriate. Nevertheless, it is worth emphasising that the comparison between the two studies should be treated with caution mainly because the average size of the sampled companies in Oakden, Friedland and Périgny (2001) is relatively large, whereas there is a considerable diversity of company size in the present study.

In order to investigate whether the results are similar for all types of insurance, it is considered necessary to analyse the insurance products offered by the general insurers who responded to the survey. At the end of the questionnaire, the respondents were asked about what kind of insurance contracts their companies sold. Seven classes of business were listed, including the class of "other". Respondents were allowed to tick more than one response. Thus, the percentages do not add to 100. The actual numbers as well as the percentages are found in Table 6.3.

Table 6.3: The class of business (Non-Life)

Class of business	Number (percentage) of respondents
Accident & health	14 (41%)
Marine, aviation and transport	4 (12%)
Liability	10 (29%)
Motor	8 (24%)
Property	18 (53%)
Miscellaneous & pecuniary loss	14 (41%)
Other	10 (29%)

The above table reveals that more than half of the respondents reported selling property insurance contracts. This is generally representative of the whole market in which property insurance has been the largest line of business (Post Index, 2000). Forty one per cent reported selling accident & health insurance contracts, and the same percentage miscellaneous & pecuniary loss insurance contracts. Approximately 30 per cent indicated that liability related insurance contracts were sold within their organisations. A number of the responding organisations sold insurance contracts which were not assigned to the categories listed such as travel, pet, and legal expenses insurance, etc.

In general the following analyses of the non-life data will focus on the non-life insurance industry as a whole. A number of analyses by different forms of insurance will also be conducted and their results reported where appropriate.

1. Use of DFA related techniques

In order to obtain a broad overview of the use of DFA related techniques in the general insurance industry, the first question in the survey asked the respondents whether their organisations used any of the following techniques.

- Sensitivity testing
- Scenario testing
- Stochastic simulation

The respondents were allowed to tick more than one response to this question. Thus, the percentages for this question do not add to 100. The results of the use of DFA techniques are provided in Table 6.4.

Table 6.4: The use of DFA related techniques (Non-Life)

DFA technique	All	A&H	MAT	L	M	P	M&PL	O
Sensitivity testing	9 (26%)	4 (29%)	1 (25%)	3 (30%)	3 (38%)	5 (28%)	4 (29%)	3 (30%)
Scenario testing	12 (35%)	4 (29%)	1 (25%)	4 (40%)	3 (38%)	6 (33%)	5 (36%)	5 (50%)
Stochastic simulation	4 (12%)	1 (7%)	1 (25%)	1 (10%)	2 (25%)	2 (11%)	1 (7%)	2 (20%)
None of the above	20 (59%)	9 (64%)	2 (50%)	5 (50%)	3 (38%)	11 (61%)	8 (57%)	4 (40%)

Note:
1. All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned
2. * Significant at the 0.05 level; **significant at the 0.01 level.

The most striking result is that 59 per cent of the survey respondents did not use any of these techniques at the time of the survey. This confirms that the financial modelling techniques were used by less than half of the non-life insurance companies surveyed. Scenario testing was the most popular technique used in the industry. Of the respondents, 35 per cent reported using scenario testing, whereas 26 per cent sensitivity testing. Only four general insurers (12 per cent) indicated that stochastic simulation was employed within their organisations. Overall it seems that the use of financial techniques, stochastic simulation in particular, in the general insurance industry was limited.

After the use of DFA related techniques by all companies was discussed above, it would be interesting to investigate whether the results were similar for all types of insurance or whether there was any differentiation between them. As were in Table 6.3 insurance contracts sold by the respondents were divided into seven categories. The actual numbers and percentages of the use of the techniques by companies offering different types of insurance are also presented in Table 6.4. It appears that the results were similar for all types of insurance. Moreover, the Fisher's exact test was conducted repeatedly to determine whether there is a relation between each of the types of insurance offered ("Yes (Code = 1)" and "No (Code=2)") and each of the DFA techniques used ("Yes (Code = 1)" and "No (Code=2)"). The Fisher's exact test was selected because it is appropriate when members of two independent groups can fall into one of the two mutually exclusive categories. Since in this research there were seven types of insurance and four categories of the use of DFA techniques, the total number of null hypotheses to be tested is 28. For instance, one of the null hypotheses is as follows:

H_0: There is no relation between the offer of accident & health insurance and the use of sensitivity testing

The alternative hypothesis is as follows:

H_1: There is a relation between the offer of accident & health insurance and the use of sensitivity testing

The associated p-value is 1. This indicates that the null hypothesis of no relation between the offer of accident & health insurance and the use of sensitivity testing cannot be rejected at the 0.05 level. That is, we cannot say, on the basis of the survey data, that there is a significant association between them.

The remaining 27 null hypotheses were also tested one by one using the Fisher's exact test. All the null hypotheses cannot be rejected at the 0.05 level. The conclusion is that statistically speaking there is no relation between each of the types of insurance offered and the DFA techniques used. That is, there is no tendency towards the use of any of the DFA techniques by companies offering any of the insurance products in particular. This seems to imply that the type of insurance offered was not a determinant of the use of these techniques, possibly due to the small sample size. Also, of the sample data used in the study, 88 per cent of the firms are multi-line insurers offering more than one insurance product. The attributes of different types of insurance which might have effect on the choice of techniques may "average out".

Having considered the use of the financial techniques by type of techniques employed, it is also pertinent to examine that by number. This analysis identifies the number of techniques used by the non-life companies surveyed. It is also an indicator of the use of financial techniques in this industry.

Again, Table 6.5 confirms that the use of these techniques was restricted. Only two respondents (six per cent) employed all these three techniques. Twenty per cent used two of these techniques, while 15 per cent only used one. Of the respondents who reported only using one technique, it is interesting to note that 80 per cent employed scenario testing, whereas 20 per cent used stochastic simulation. None of them only used sensitivity testing. Since the main difference between scenario testing and sensitivity testing is that the former changes a group of consistent variables at a time, the latter changes a variable at a time. Respondents who were able to use scenario testing were supposed to be also able to do sensitivity testing. It seems that the respondents preferred scenario testing to sensitivity testing probably because the results from the former were relatively reliable and comprehensive, and the respondents felt no need to do the latter. It is also interesting to note that 86 per cent of the respondents who used two of these techniques employed sensitivity testing and scenario testing, while the rest sensitivity testing and stochastic simulation. This indicates that there probably existed a "technical gap" between scenario testing and stochastic simulation. Lack of resources could be the main reason why this gap existed. There could be other reasons. For example, most of the respondents might simply believe that scenario testing performed better than stochastic simulation or they might think that scenario testing had already met their needs. Although the question of which techniques to use is largely a matter of judgement, cost also figures in the decision. Complex models using stochastic simulation have become more affordable due to advances in methodology and declines in the cost of information technology. Accordingly, the trend in recent years has been towards more complex modelling. Despite this trend and the methodological advances of recent years, some remain skeptical about the value of stochastic modelling and favour using scenario testing. This might be one of the reasons why stochastic simulation was not common in the general insurance industry. Table 6.5 also presents the results for different types of insurance offered. It seems that there is no differentiation between them.

Table 6.5: The number of DFA related techniques used (Non-Life)

Number of DFA techniques used	All	A&H	MAT	L	M	P	M&PL	O
0	20 (59%)	9 (64%)	2 (50%)	5 (50%)	3 (38%)	11 (61%)	8 (57%)	4 (40%)
1	5 (15%)	1 (7%)	1 (25%)	2 (20%)	2 (24%)	2 (11%)	2 (14%)	3 (30%)
2	7 (20%)	4 (29%)	1 (25%)	3 (30%)	3 (38%)	4 (22%)	4 (29%)	2 (20%)
3	2 (6%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (6%)	0 (0%)	1 (10%)

Note:
All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned

2. Application of DFA related techniques

The second question in the survey asked the respondents to indicate the applications of the DFA related techniques within their organisations. Respondents were allowed to choose more than one response from ten possible ones.

The results are shown in Table 6.6. More than half of the respondents reported that these DFA related techniques were used to evaluate reinsurance programmes (64 per cent), help develop a business plan (63 per cent), do solvency testing (57 per cent), and price insurance contracts (51 per cent) within their organisations. Only four non-life insurance firms reported using the techniques for the purpose of capital allocation. However, these techniques were rarely used to optimise asset allocation, or evaluate mergers and acquisitions. It is also interesting to note that no respondent reported using the techniques for distributing surplus by line of business and for communicating the results with rating agencies. One respondent who ticked the box for "other" stated that these techniques were also used to evaluate financial disaster such as stock market crash and simultaneous failure of reinsurance companies.

On the whole, it seems that non-life firms tend to apply DFA techniques to underwriting related operations such as the evaluation of reinsurance programmes and the pricing of insurance contracts, possibly because they relatively focus on underwriting activities compared to life insurers. Evaluating reinsurance contracts is a prime application of DFA models due to the potential use of reinsurance to control some sources of operation risk and catastrophic risk. Also, these models are often applied to pricing because most of general insurers are, more or less, exposed to underwriting risk. As for solvency, it is the main concern of management of all insurers.

As evidenced in Chapter two, the underwriting performance of UK non-life companies has been poor. Since there are cyclical changes in the underwriting performance of non-life business, non-life companies should try to apply these techniques to investment related operations and further improve investment returns in order to enjoy good overall company performance.

Table 6.6 also shows the results for different forms of insurance offered. Three observations can be made based on these results. First, the accident & health insurance insurers reporting using DFA techniques all reported employing these techniques to price insurance contracts. Since the purchase of accident & health insurance is not mandatory, consumers will not buy the product if there are significant price increases. Compared to other types of general insurance the price elasticity of demand of accident & health insurance is relatively high and accordingly pricing is of particular importance to these insurers. As will be shown later, these insurers using scenario testing all included *pricing* in scenarios. In addition, as evidenced in Table 6.4, only one of these companies reported using stochastic simulation. This implies that stochastic simulation was seldom used to price insurance contracts by these organisations. In other words, sensitivity testing and scenario testing were the main techniques for pricing. Second, the companies offering marine, aviation and transport insurance all reported using the techniques to evaluate reinsurance programmes and price insurance contracts. Third, the motor insurers all reported that the techniques were used to evaluate reinsurance programmes. It should be noted that there were only two marine, aviation and transport insurers reported using these techniques. Due to the very small number of respondents in this category, the second observation should be treated with caution.

Table 6.6: The application of DFA related techniques used (Non-Life)

Application of DFA techniques	All	A&H	MAT	L	M	P	M&PL	O
Solvency testing	8 (57%)	2 (40%)	0 (0%)	3 (60%)	2 (40%)	5 (71%)	4 (67%)	2 (33%)
Capital allocation	4 (29%)	1 (20%)	1 (50%)	3 (60%)	3 (60%)	3 (43%)	2 (33%)	1 (17%)
Evaluate reinsurance programmes	9 (64%)	4 (80%)	2 (100%)	4 (80%)	5 (100%)	6 (86%)	4 (67%)	4 (67%)
Help develop business plan	9 (63%)	3 (60%)	1 (50%)	3 (60%)	2 (40%)	4 (57%)	4 (67%)	4 (67%)
Pricing	7 (51%)	5 (100%)	2 (100%)	3 (60%)	2 (40%)	5 (71%)	5 (83%)	3 (40%)
Asset allocation	1 (7%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (17%)
Surplus allocation	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Evaluate merger and acquisition	1 (7%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (14%)	0 (0%)	0 (0%)
Communicate the results with rating agencies	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Other	1 (7%)	1 (20%)	0 (0%)	1 (20%)	0 (0%)	1 (14%)	1 (17%)	1 (17%)

Note:
All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned

3. Scenario testing related issues

When asked about the number of scenarios run in scenario testing, 84 per cent of the respondents who used scenario testing ran less than ten scenarios on a regular basis. These results could be broadly in line with those reported by Oakden, Friedland and Périgny (2001) who found that on average Canadian property and casualty insurance and reinsurance companies included more than six scenarios. One respondent stated that the number of scenarios used was between 11-20 and the other 31-40.

It appears that non-life insurance firms generally only used a relatively small number of scenarios in scenario testing. There are two factors which can explain why few scenarios were used. The first is that many non-life firms were relatively incapable of generating scenarios, and accordingly their capability of employing financial techniques was limited. A second explanation for the use of a small number of scenarios reported in this study is that non-life respondents might simply consider it unnecessary to use a large number of scenarios in scenario testing. This can be confirmed by a number of additional comments volunteered by the respondents to the non-life survey. For example, one finance director from a company offering accident & health insurance commented:

"*Generally speaking, we normally run about six scenarios half yearly. Due to the nature of our business, there is no need to run many scenarios.*"

A similar comment was made by the actuary of a non-life company who reported running less than ten scenarios on a regular basis:

"*We only run a very small number of scenarios, which suffices our needs.*"

The views expressed in the two quotations presented above can be regarded as representative. On the whole, the additional comments volunteered by the survey respondents suggest that there was no need to run a lot of scenarios, possibly due in part to the nature of business. This seems to imply that in the past the lack of simulations was acceptable to non-life companies. Nevertheless, at present non-life companies operate in a fundamentally changed business environment, and face challenges from both underwriting and investment operations such as adverse claims developments and subdued financial markets. A wide range of scenarios which might beyond the actuary's preconceived notions could happen. Therefore, using stochastic simulations to generate a large number of scenarios will become increasingly important to non-life firms.

The next question asked how often scenario tests were run, giving the following seven answers to choose from: daily, weekly, monthly, quarterly, half yearly, annually, and "other". Respondents were allowed to check only one answer. The results are shown in Table 6.7. Monthly (33 per cent) and half yearly (33 per cent) were the most common answers to this question. It is interesting to note that no respondent reported conducting scenario tests daily or weekly. In contrast, banks usually conduct scenario tests relatively frequently. According to the survey of 43 major commercial and investment banks by Fender and Gibson (2001), most of the banks surveyed reported running stress testing (one kind of scenario testing) daily, weekly and monthly. It is generally agreed that the frequency of scenario testing is influenced by both the technical burden of conducting scenario tests and the frequency of shifts in portfolio positions. For general insurers, frequent scenario tests sometimes become a burden and shifts in portfolio positions are relatively infrequent. This is probably the main reason why non-life firms, in general, run scenario tests less frequently than banks.

Table 6.7: The frequency of scenario tests conducted (Non-Life)

Frequency	All	A&H	MAT	L	M	P	M&PL	O
Daily	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Weekly	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Monthly	4 (33%)	2 (50%)	1 (100%)	2 (50%)	1 (34%)	2 (33%)	3 (60%)	1 (20%)
Quarterly	2 (17%)	1 (25%)	0 (0%)	0 (0%)	1 (33%)	1 (17%)	1 (20%)	0 (0%)
Half yearly	4 (33%)	1 (25%)	0 (0%)	2 (50%)	1 (33%)	3 (50%)	1 (20%)	2 (40%)
Annually	2 (17%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (40%)
Other	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Note:
All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned

Question five listed 19 risk categories and asked the respondents using scenario testing whether any of these risk categories were included in their scenarios, i.e. whether they varied any of the assumptions regarding these risk categories. The results are shown in Table 6.8. The most striking result is that 83 per cent of the survey respondents reported including *levels of new business* in the scenarios. The following quotation, from the actuary of a non-life company, is indicative of the concern of many respondents who included this risk category as one of the scenarios.

"High levels of new business could have a huge impact on the solvency of the company."

High levels of new business might indicate favourable business expansion. Nevertheless, an unusual increase in the levels of new business often seriously depletes the capacity of the company. It is hazardous for a non-life insurer to underwrite a great deal of new business before reinsurance agreements can be arranged. It is in particular the case if the size of the company is small.

In addition, the risk categories, which were included in scenarios by more than half of the respondents, are *expenses* (75 per cent), *frequency and severity* (75 per cent), *premium volume* (75 per cent), *risk of reinsurer default* (67 per cent), *future investment conditions* (58 per cent), *pricing* (58 per cent), and *interest rate level* (58 per cent). The possible reasons why the above-mentioned risk categories were included as scenarios were discussed below.

An insurer's expense structure affects both its financial results and its relative competitive position in the insurance market. Expenses can be divided into two categories: claim management and non-claim management expenses. Claim management expenses are the expenses associated with loss adjustment, while non-claim management expenses cover all the different kinds of administrative and operational costs of an insurer, such as costs for marketing, underwriting, and sales commissions. In practice different specifications have been used for these two components. In some cases, claim management expenses and incurred losses have been modelled in the aggregate using relatively simple equations, while in other instances they have been modelled separately.

As for non-claim management expenses, in the past they were usually assumed to be a function of the premium volume in insurance modelling. Moreover, the ratio of expenses to premium volume was in general assumed to be fixed. Nonetheless, in the present it is considered desirable to allow for the changes in expense ratios in practical models because the modelling results can be quite sensitive to these changes. In addition, it is worth emphasising that premium volume is unavoidably subject to uncertainty which needs not proportionally affect the expenses and that the expenses may change simply due to the competitive market. Therefore, it is no longer appropriate to assume the constant ratio of expenses to premium volume. Moreover, over the years expense management has become increasingly important to insurers. Insurers who implement an inappropriate expense management strategy or inadequately implement the chosen strategy, are prone to expense risk. These are probably the most important reasons why a large proportion of the respondents tested variations in this assumption.

The loss cost, also known as the pure premium in non-life insurance, is the expected value of the incurred losses per unit of exposure and is defined as the product of frequency and severity. Frequency is the number of claims per exposure unit and severity is the average loss per claim. Since these two components determine the loss cost, it is important for non-life insurance firms to test variations in the assumption regarding *frequency and severity* while conducting scenario testing. It is worth noting that the number of claims and the size of each claim are generally stochastic in practical applications.

Insurance business can be described as a balance of a series of cash inflows and outflows. Premium volume (income) is one of the main entries of cash inflows in the comprehensive models of insurance business. As previously mentioned, premium volume is unavoidably subject to uncertainty. This is possibly due in part to the fact that the insurance market and economic environments are changing all the time. Premium volume mainly depends on premium rates which in practice are normally under management control. The main purpose of the dynamics of premium control is to keep the modelling outcomes stable. In fact, with a view to making modelling results meaningful as well as stable in the long run management should take into account the interaction between the market condition and premium rating. Moreover, premium income is very important for the survival of insurance companies. The premiums and the return on investments together are supposed to be sufficient to cover claims and other expenses. Therefore, it is necessary for insurance companies to test variations in the assumption regarding *premium volume*.

Risk of reinsurer default is also a common risk category in the scenario tests conducted by non-life insurance companies. This is because in most cases general insurers rely on reinsurance to a great extent in order to stabilise earnings, provide protection against catastrophic losses, and control some sources of operating risk. Smaller insurers are able to insure exposures they could not otherwise handle within the bounds of safety. In some instances, reinsurer default may lead to insurer insolvency. This is the reason why a large proportion of non-life insurance firms included this category in scenarios.

As evidenced in Chapter two, the underwriting results of the general insurance industry had been poor during the period 1986-1999. Although the non-life market has been hardening over the past three years, many insurers are still making underwriting losses. Consequently, these insurers have to achieve good investment performance in order to offset the losses in underwriting. Nonetheless, the future investment conditions are uncertain. Therefore non-life insurers who are highly exposed to investment risk tested variations in the assumption regarding *future investment conditions*.

In times of bad investment results, general insurers usually have to increase premium rates in order to improve underwriting results and survive. Nevertheless, premium cycles are sometimes induced by competitive company strategies. For instance, companies with surplus capital may seek to expand market share by cutting prices. Since the pricing policy has much impact on the insurance business, *pricing* was included as one of risk categories by a significant proportion of the non-life respondents.

As evidenced in Chapter two, the non-life insurance industry as a whole on average invested 24.4 per cent of its funds in bonds during the period 1986-1999. Bond portfolio account for a high proportion of the invested assets of non-life companies and as a result bond investment earnings are important for their investment performance. Since bond returns mainly depend on the level of interest rates, the investment performance of this industry is closely related to *interest rate level*. This is the main reason why non-life insurers included it in their scenarios.

As reviewed in Chapter two, scenarios considered significant and included in more than one-half of the DCAT reports of the companies surveyed by Oakden, Friedland and Périgny (2001) include *frequency and severity*, *understatement of unpaid claim liability*, *single catastrophic loss*, *increase in inflation*, *increase in interest rate*, and *deterioration in asset values*. Of these six scenarios, *single catastrophic loss* and *increase in inflation* were not listed in the present survey as the responses of Question five. *Frequency and severity*, and *interest rate level* (*increase in interest rate*) are the scenarios which were found significant both in the present survey and in the report by Oakden, Friedland and Périgny. However, the remaining two significant scenarios, *understatement of unpaid claim liability* and *deterioration in asset values*, reported by Oakden, Friedland and Périgny were not used by more than half of the survey respondents. How can the difference between the findings of the present survey and those reported by Oakden, Friedland and Périgny (2001) be reconciled? There could be two reasons behind this. The first is that the companies interviewed by Oakden, Friedland and Périgny are the largest Canadian property and casualty insurance and reinsurance companies whose nature of business might be different from those in the present survey population. The second reason is that the economic and market conditions of UK and Canada are different. Thus, the risk categories considered by the insurance companies in these two countries were accordingly slightly different.

The relationship between the type of insurance offered and the risk category included was investigated and the results are also shown in Table 6.8. Due to the unreliability of Chi-square tests when a number of expected frequencies within cells are less than five, we collapsed the data for each type of insurance to two by two in order to perform the Fisher's exact test. The "No" category of the inclusion of the risk category can be merged into the "N/A" category, so the whole analysis boils down into an investigation of the relationship between the type of insurance offered ("Yes (Code = 1)" and "No (Code=2)") and the inclusion of the risk category ("Yes (Code = 1)" and "No or N/A (Code=2)"). In order to simplify the presentation of the results, only statistically significant results are discussed here. One observation can be made based on these results.

This observation is that most of the companies (67 per cent) offering motor insurance tested variations in the assumption regarding *liquidity*. A p-value of 0.045 was obtained from the Fisher's exact test, confirming that the null hypothesis of no relation between the offer of motor insurance and the inclusion of *liquidity* in scenarios can be rejected at a level of significance of 0.05. This indicates that the companies offering motor insurance are more likely to include *liquidity* in scenarios. The UK motor insurance industry has undergone some rapid changes in the past decade. One of the main changes is that motor insurance companies increase car insurance premiums to a great extent in order to return to profit. In fact, motor insurance has been underpriced for most of the 1990s. In the present time the motor insurance industry as a whole is losing money due to the fact that more policyholders are taking insurance companies to court and claiming compensation. The huge underwriting losses mean that many companies need to generate cash quickly. Therefore, *liquidity* could be one of the main concerns of motor insurers. This is probably the main reason why *liquidity* was included in scenarios by them.

Table 6.8: The risk category included in scenarios (Non-Life)

Risk category	All			A&H			MAT		
	Yes	No	N/A	Yes	No	N/A	Yes	No	N/A
Future investment conditions	7 (58%)	1 (9%)	4 (33%)	3 (75%)	1 (25%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)
Levels of new business	10 (83%)	0 (0%)	2 (17%)	4 (100%)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)
Expenses	9 (75%)	1 (8%)	2 (17%)	2 (50%)	1 (25%)	1 (25%)	0 (0%)	0 (0%)	1 (100%)
Taxation	3 (25%)	4 (33%)	5 (42%)	1 (25%)	1 (25%)	2 (50%)	0 (0%)	0 (0%)	1 (100%)
Effects of asset defaults	1 (8%)	6 (50%)	5 (42%)	1 (25%)	1 (25%)	2 (50%)	0 (0%)	0 (0%)	1 (100%)
Risk of reinsurer default	8 (67%)	1 (8%)	3 (25%)	2 (50%)	0 (0%)	2 (50%)	0 (0%)	0 (0%)	1 (100%)
Frequency and severity***	9 (75%)	1 (8%)	2 (17%)	3 (75%)	1 (25%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)
Pricing	7 (58%)	0 (0%)	5 (42%)	4 (100%)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)
Misestimation of policy liabilities***	3 (25%)	2 (17%)	7 (58%)	1 (25%)	0 (0%)	3 (75%)	0 (0%)	0 (0%)	1 (100%)
Deterioration of asset values***	4 (33%)	3 (25%)	5 (42%)	1 (25%)	1 (25%)	2 (50%)	0 (0%)	0 (0%)	1 (100%)
Government and political action	2 (17%)	6 (50%)	4 (33%)	0 (0%)	2 (50%)	2 (50%)	0 (0%)	0 (0%)	1 (100%)
Off balance sheet (e.g. derivatives)	0 (0%)	2 (17%)	10 (83%)	0 (0%)	1 (25%)	3 (75%)	0 (0%)	0 (0%)	1 (100%)
Unexpected inflation	2 (16%)	5 (42%)	5 (42%)	1 (25%)	1 (25%)	2 (50%)	0 (0%)	0 (0%)	1 (100%)
Interest rate level***	7 (58%)	2 (17%)	3 (25%)	2 (50%)	1 (25%)	1 (25%)	0 (0%)	0 (0%)	1 (100%)
Equity returns	4 (33%)	2 (17%)	6 (50%)	1 (25%)	1 (25%)	2 (50%)	0 (0%)	0 (0%)	1 (100%)
Premium volume	9 (75%)	0 (0%)	3 (25%)	4 (100%)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)
Leverage	0 (0%)	3 (25%)	9 (75%)	0 (0%)	1 (25%)	3 (75%)	0 (0%)	0 (0%)	1 (100%)
Liquidity	2 (16%)	5 (42%)	5 (42%)	0 (0%)	2 (50%)	2 (50%)	0 (0%)	0 (0%)	1 (100%)
Asset mix	4 (33%)	3 (25%)	5 (42%)	1 (25%)	1 (25%)	2 (50%)	0 (0%)	0 (0%)	1 (100%)

Note:

1. All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned
2. *Significant at the 0.05 level; **significant at the 0.01 level.
3. ***Scenarios considered significant and included in more than one-half of the DCAT reports of the companies surveyed by Oakden, Friedland and Périgny (2001).
4. N/A: not applicable

Table 6.8: The risk category included in scenarios (Non-Life) (continued)

Risk category	L			M			P		
	Yes	No	N/A	Yes	No	N/A	Yes	No	N/A
Future investment conditions	4 (100%)	0 (0%)	0 (0%)	3 (100%)	0 (0%)	0 (0%)	6 (100%)	0 (0%)	0 (0%)
Levels of new business	4 (100%)	0 (0%)	0 (0%)	3 (100%)	0 (0%)	0 (0%)	6 (100%)	0 (0%)	0 (0%)
Expenses	2 (50%)	1 (25%)	1 (25%)	2 (67%)	0 (0%)	1 (33%)	4 (66%)	1 (17%)	1 (17%)
Taxation	0 (0%)	2 (50%)	2 (50%)	1 (33%)	0 (0%)	2 (67%)	1 (17%)	2 (33%)	3 (50%)
Effects of asset defaults	1 (25%)	1 (25%)	2 (50%)	0 (0%)	67%	1 (33%)	1 (17%)	2 (33%)	3 (50%)
Risk of reinsurer default	3 (75%)	0 (0%)	1 (25%)	2 (67%)	0 (0%)	1 (33%)	4 (66%)	1 (17%)	1 (17%)
Frequency and severity***	2 (50%)	1 (25%)	1 (25%)	2 (67%)	0 (0%)	1 (33%)	4 (66%)	1 (17%)	1 (17%)
Pricing	3 (75%)	0 (0%)	1 (25%)	1 (33%)	0 (0%)	2 (67%)	5 (83%)	0 (0%)	1 (17%)
Misestimation of policy liabilities***	1 (25%)	1 (25%)	2 (50%)	1 (33%)	0 (0%)	2 (67%)	1 (17%)	2 (33%)	3 (50%)
Deterioration of asset values***	3 (75%)	0 (0%)	1 (25%)	1 (33%)	1 (33%)	1 (33%)	4 (67%)	0 (0%)	2 (33%)
Government and political action	1 (25%)	2 (50%)	1 (25%)	1 (33%)	1 (33%)	1 (33%)	1 (17%)	3 (50%)	2 (33%)
Off balance sheet (e.g. derivatives)	0 (0%)	2 (50%)	2 (50%)	0 (0%)	0 (0%)	3 (100%)	0 (0%)	2 (33%)	4 (67%)
Unexpected inflation	0 (0%)	2 (50%)	2 (50%)	0 (0%)	1 (33%)	2 (67%)	1 (17%)	3 (50%)	2 (33%)
Interest rate level***	3 (75%)	0 (0%)	1 (25%)	2 (67%)	0 (0%)	1 (33%)	5 (83%)	0 (0%)	1 (17%)
Equity returns	2 (50%)	1 (25%)	1 (25%)	1 (33%)	0 (0%)	2 (67%)	3 (50%)	1 (17%)	2 (33%)
Premium volume	4 (100%)	0 (0%)	0 (0%)	3 (100%)	0 (0%)	0 (0%)	6 (100%)	0 (0%)	0 (0%)
Leverage	0 (0%)	2 (50%)	2 (50%)	0 (0%)	0 (0%)	3 (100%)	0 (0%)	3 (50%)	3 (50%)
Liquidity	1 (25%)	2 (50%)	1 (25%)	2 (67%)*	0 (0%)*	1 (33%)*	1 (17%)	3 (50%)	2 (33%)
Asset mix	1 (25%)	2 (50%)	1 (25%)	1 (33%)	1 (33%)	1 (33%)	2 (34%)	2 (33%)	2 (33%)

Note:

1. All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned
2. *Significant at the 0.05 level; **significant at the 0.01 level.
3. ***Scenarios considered significant and included in more than one-half of the DCAT reports of the companies surveyed by Oakden, Friedland and Périgny (2001).
4. N/A: not applicable

Table 6.8: The risk category included in scenarios (Non-Life) (continued)

Risk category	M&PL			O		
	Yes	No	N/A	Yes	No	N/A
Future investment conditions	4 (80%)	0 (0%)	1 (20%)	2 (40%)	0 (0%)	3 (60%)
Levels of new business	5 (100%)	0 (0%)	0 (0%)	3 (60%)	0 (0%)	2 (40%)
Expenses	3 (60%)	1 (20%)	1 (20%)	2 (40%)	1 (20%)	2 (40%)
Taxation	0 (0%)	3 (60%)	2 (40%)	0 (0%)	2 (40%)	3 (60%)
Effects of asset defaults	1 (20%)	1 (20%)	3 (60%)	1 (20%)	1 (20%)	3 (60%)
Risk of reinsurer default	3 (60%)	0 (0%)	2 (40%)	4 (80%)	0 (0%)	1 (20%)
Frequency and severity***	4 (80%)	1 (20%)	0 (0%)	3 (60%)	1 (20%)	1 (20%)
Pricing	5 (100%)	0 (0%)	0 (0%)	2 (40%)	0 (0%)	3 (60%)
Misestimation of policy liabilities***	1 (20%)	1 (20%)	3 (60%)	2 (40%)	0 (0%)	3 (60%)
Deterioration of asset values***	2 (40%)	0 (0%)	3 (60%)	1 (20%)	1 (20%)	3 (60%)
Government and political action	0 (0%)	3 (60%)	2 (40%)	1 (20%)	1 (20%)	3 (60%)
Off balance sheet (e.g. derivatives)	0 (0%)	2 (40%)	3 (60%)	0 (0%)	1 (20%)	4 (80%)
Unexpected inflation	1 (20%)	3 (60%)	1 (20%)	1 (20%)	1 (20%)	3 (60%)
Interest rate level***	3 (60%)	1 (20%)	1 (20%)	2 (40%)	0 (0%)	3 (60%)
Equity returns	1 (20%)	1 (20%)	3 (60%)	2 (40%)	0 (0%)	3 (60%)
Premium volume	100%	0 (0%)	0 (0%)	2 (40%)	0 (0%)	3 (60%)
Leverage	0 (0%)	2 (40%)	3 (60%)	0 (0%)	1 (20%)	4 (80%)
Liquidity	0 (0%)	2 (40%)	3 (60%)	0 (0%)	2 (40%)	3 (60%)
Asset mix	1 (20%)	1 (20%)	3 (60%)	2 (40%)	0 (0%)	3 (60%)

Note:

1. All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned
2. *Significant at the 0.05 level; **significant at the 0.01 level.
3. ***Scenarios considered significant and included in more than one-half of the DCAT reports of the companies surveyed by Oakden, Friedland and Périgny (2001).
4. N/A: not applicable

4. Determinants of company performance

Question six listed 11 possible performance determinants and requested the respondents to rate the importance of these determinants on a five-point scale, "1" being least important and "5" being most important. Table 6.9 presents the means of the importance ratings given by the respondents for these determinants in decreasing order of importance rating. These results reveal that the survey respondents perceived *stability of underwriting operation, solvency margin, reinsurance dependence, interest rate level*, and *stability of asset structure* to be relatively important to company performance (i.e. mean importance rating more than "3"). Not surprisingly, *stability of underwriting operation* was given the highest mean importance rating in terms of company performance. This is because underwriting operation is the core business of a non-life insurer and is, therefore, of particular importance. *Solvency margin* was also one of the main concerns of the non-life companies surveyed, possibly due in part to the fact that financially sound companies are better able to adhere to the specified underwriting guidelines. In general, adhering to these guidelines will do the companies good in the long run. In addition, *reinsurance dependence* was ranked third by the respondents. This is because non-life companies rely heavily on reinsurance. This is particularly the case for small companies because their capacity is generally limited. *Interest rate level* is the investment related determinant given the highest importance rating. This is because non-life companies invested a high proportion of funds in fixed income securities and as a result *interest rate level* has a great impact on investment performance of the companies. *Stability of asset structure* is the second investment related determinant considered relatively important. In general a good asset structure is important to non-life companies and a dramatic change in asset structure might indicate that the company is in financial trouble.

In contrast, the respondents indicated that *leverage*, *company size*, *liquidity*, *unexpected inflation*, *interest rate change*, and *equity returns* are relatively unimportant to company performance (i.e. mean importance rating less than "3"). It is worth noting that the mean importance rating of *equity returns* was only 2.8. It seems that *equity returns* was not a very important company performance determinant. This is possibly because non-life companies in general invested most of their funds in bonds instead of equities. As evidenced in Chapter two the non-life insurance industry as a whole invested 12.5 per cent and 24.4 per cent of its funds in equities and bonds respectively during the period

1986-1999. Moreover, since the performance of the stock market was poor as of the time the non-life survey was administered, many companies further reduced the proportion of their investments in equities. This could be the reason why *equity returns* was not given a high importance rating.

The mean importance ratings by different forms of insurance offered are also presented in Table 6.9. Two main conclusions can be drawn from these results. The first is that the results for different lines of business were broadly the same. *Stability of underwriting operation, solvency margin*, and *reinsurance dependence* were the top three performance determinants across these lines of business. The second conclusion is that the non-life companies offering different types of insurance all considered underwriting-related determinants more important than investment-related determinants. This confirms the common perception that the management of non-life companies has been placing great emphasis on underwriting instead of investment operations. For example, the actuary of a leading international general insurance and reinsurance company stated:

"*In general insurance and reinsurance it is hard enough to get a good estimate of the mean expected losses. Trying to quantify the higher moments of loss distributions and of correlations between classes is even harder to do properly. Assets are a second-order issue....*"

Nevertheless, since the underwriting performance has been poor it is very likely that in the future investment operations will play an increasingly important role in company performance.

Table 6.9: The mean importance rating of performance determinants (Non-Life)

Performance determinant	All	A&H	MAT	L	M	P	M&PL	O
Stability of underwriting operation	3.7	3.2	4.5	4	4.6	4.1	4	3.2
Solvency margin	3.4	3.5	4.5	3.4	3.6	3.6	4	3.5
Reinsurance dependence	3.3	3.2	3.5	3.6	3.6	3.4	3	4
Interest rate level	3.1	3	2.5	3.2	3.6	3.4	3	2.3
Stability of asset structure	3.1	3	2.5	3	3.4	2.8	2.7	3
Equity returns	2.8	3.2	3.5	3.2	2.8	3.4	2.6	3
Interest rate change	2.7	2.6	2	2.8	3	2.9	2.6	2.3
Unexpected inflation	2.6	2.4	2	3	2.6	2.6	2.4	2.7
Liquidity	2.6	2.4	2.5	2.4	3	2.5	2.6	2.5
Company size	2.5	2.4	1.5	2	2	2.4	2.3	2.2
Leverage	1.6	1.6	2.5	1.8	1.8	1.6	1.6	2.2

Note:
All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned

5. Modelling related issues

Respondents were explicitly asked which driving factors they used and which DFA approaches (deterministic or stochastic) they employed in the modelling of DFA. Economic variables are often modelled as driving factors in financial modelling. The way economic variables are modelled can reflect the modelling capability of the company and the complexity of the model used. The following economic variables were listed for the respondents to choose:

- Term structure of interest rates
- Inflation
- Equity returns
- Currency rates
- Credit spreads

Table 6.10 reports the results of the use of the five economic variables. Three main conclusions can be drawn based on these results. First, on average more than 80 per cent of the survey respondents did not model these economic variables with the exception of inflation, which approximately half of the respondents modelled. There are two possible reasons why *inflation* was the most frequently modelled driving factor. The first is that practitioners in general were relatively familiar with *inflation* because it is the driving factor in the Wilkie investment model, which is extensively used in the UK insurance industry. Moreover, modelling inflation is considered relatively easy. For instance, a respondent stated the reason why inflation was used as the driving factor by commenting that "*among these economic variables inflation is relatively easy to model*". The second reason is that *inflation* has relatively direct impact on both sides of the balance sheet compared to other economic variables. On the asset side, there seems some correlation between inflation and asset returns due to the compensation for the effect of inflation required by investors. On the liability side, because it takes time to settle claims inflation can have profound effects for the costs of outstanding claims, especially in long-tail lines of business such as liability insurance. Technical reserves which must be established at the end of each year should reflect the impact of inflation and will be accordingly affected by it.

The second conclusion is that most of those who modelled inflation did it in a deterministic way. This finding suggests that the deterministic models may be crude, but at least the results could be accepted as approximately correct. In addition, developing a stochastic model for inflation is not necessarily essential for a general insurer. The use of a deterministic or stochastic approach mainly depends on the applications of the model. For instance, it may be acceptable and adequate to model inflation deterministically when projecting the financial strength of an insurance company over the next few years. Nevertheless, modelling inflation in a stochastic way would be of particular value in assessing the ability of an insurer to withstand the wide range of possible changes in the external economic conditions.

Finally, among the respondents who modelled the economic variables other than *inflation* it appears that there is no obvious difference in adopting a deterministic or stochastic approach. This finding is somewhat surprising and contradictory to the previous inference that in the non-life insurance industry there probably existed a "technical gap" between scenario testing and stochastic simulation. How can this contradiction be reconciled? As previously noted, modelling inflation was relatively simple to practitioners. Generally speaking, the insurers which modelled the rest of variables were large companies with complicated asset/product portfolios. These companies in general were able to model the variables in a stochastic approach if need be. This is the possible reason why the "technical gap" did not seem to exist in this case.

Table 6.10 also presents the results for different lines of business. Two observations can be made from these results. The first is that the surveyed companies offering accident & health insurance, marine, aviation and transport insurance, and miscellaneous & pecuniary loss insurance either modelled inflation or did not model any of the economic variables listed. There are two possible reasons behind this. First, the modelling capability of these companies might be so restricted that they were not able to model different economic variables. This suggests that for these companies, there are limitations associated with the use of modelling techniques. Second, these companies did not model various economic variables due to lack of need. This is explained by the finance director from a small non-life company offering accident & health insurance as follows:

"*The asset/product mix is simple in our company. There is no need to model any of the economic variables.*"

The second observation is that currency rates and credit spreads were seldom modelled by the non-life companies surveyed. In general only large insurers with complicated portfolios were relatively willing and able to model these economic variables. For example, one of the non-life companies surveyed reported modelling all five economic variables using a stochastic approach. This company had a complicated product mix and covered all types of general business. On the whole, the modelling capability of this company was above average. If fact, this company could be the best among the surveyed companies in terms of modelling capability. It would be interesting to further investigate how this company used the DFA techniques. Therefore, the Chief Actuary of the company was approached and interviewed. The results are reported in Chapter seven.

Table 6.10: Modelling of economic variables (Non-Life)

Economic variable	All			A&H			MAT		
	No	Yes		No	Yes		No	Yes	
		D	S		D	S		D	S
Term structure of interest rates	12 (80%)	2 (13%)	1 (7%)	5 (100%)	0 (0%)	0 (0%)	2 (100%)	0 (0%)	0 (0%)
Inflation	8 (53%)	6 (40%)	1 (7%)	3 (60%)	2 (40%)	0 (0%)	1 (50%)	1 (50%)	0 (0%)
Equity returns	12 (80%)	1 (7%)	2 (13%)	5 (100%)	0 (0%)	0 (0%)	2 (100%)	0 (0%)	0 (0%)
Currency rates	13 (86%)	1 (7%)	1 (7%)	5 (100%)	0 (0%)	0 (0%)	2 (100%)	0 (0%)	0 (0%)
Credit spreads	13 (86%)	1 (7%)	1 (7%)	5 (100%)	0 (0%)	0 (0%)	2 (100%)	0 (0%)	0 (0%)

Note:

1. All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned
2. D: deterministic approach; S: stochastic approach

Table 6.10: Modelling of economic variables (Non-Life) (continued)

Economic variable	L			M			P		
	No	Yes		No	Yes		No	Yes	
		D	S		D	S		D	S
Term structure of interest rates	5 (100%)	0 (0%)	0 (0%)	3 (60%)	2 (40%)	0 (0%)	8 (100%)	0 (0%)	0 (0%)
Inflation	3 (60%)	2 (40%)	0 (0%)	1 (20%)	4 (80%)	0 (0%)	4 (50%)	4 (50%)	0 (0%)
Equity returns	4 (80%)	1 (20%)	0 (0%)	4 (80%)	1 (20%)	0 (0%)	6 (74%)	1 (13%)	1 (13%)
Currency rates	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	7 (87%)	1 (13%)	0 (0%)
Credit spreads	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	7 (87%)	1 (13%)	0 (0%)

Note:

1. All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned
2. D: deterministic approach; S: stochastic approach

Table 6.10: Modelling of economic variables (Non-Life) (continued)

Economic variable	M&PL			O		
	No	Yes		No	Yes	
		D	S		D	S
Term structure of interest rates	7 (100%)	0 (0%)	0 (0%)	5 (83%)	0 (0%)	1 (17%)
Inflation	5 (71%)	2 (29%)	0 (0%)	4 (66%)	1 (17%)	1 (17%)
Equity returns	7 (100%)	0 (0%)	0 (0%)	5 (83%)	0 (0%)	1 (17%)
Currency rates	7 (100%)	0 (0%)	0 (0%)	5 (83%)	0 (0%)	1 (17%)
Credit spreads	7 (100%)	0 (0%)	0 (0%)	5 (83%)	0 (0%)	1 (17%)

Note:

1. All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned
2. D: deterministic approach; S: stochastic approach

When conducting a DFA analysis, the actuary should be able to model asset values and their returns over the forecast period. Whether an insurer is capable of meeting its responsibilities to its policyholders largely depends on the ability of the associated asset portfolio to support the liabilities. The next important issue on modelling is the degree of sophistication with which the assets were modelled by the respondents. The extent of sophistication depends on the modelling capability of the company, its assets and liabilities being modelled, the current market, and regulatory environment. In the questionnaire only the capability of asset modelling of the non-life companies surveyed was investigated. Five levels of modelling capability were categorised.

The simplest model is the one which can only project the total investment return. Some model assumptions can be varied from year to year. The next stage would be the ability to vary income and gains independently including investment income, and realised and unrealised gains. The ability to use separate model points for different asset classes would be considered relatively advanced. The most advanced stage would be the ability to model individual assets.

Question eight asked the respondents about the asset modelling capability within organisations. The respondents were allowed to tick more than one response. The results are summarised in Table 6.11. Forty seven per cent indicated that in each projection step the total investment return could be projected within their organisations. It is noted that a number of non-life insurance companies even did not have the most basic capability of asset modelling. Some 47 per cent of the respondents indicated that they were unable to vary the assumptions from year to year. The scenarios which can be examined by these organisations were accordingly limited to a great extent. Twenty seven per cent indicated that they were able to vary income and gains independently and the same percentage used separate model points for different asset classes for modelling purposes. None of the organisations reported that they were able to model individual assets separately. Generally speaking, the capability of asset modelling in the non-life insurance industry was very limited, possibly because this industry used to place great emphasis on underwriting instead of investment operations.

Table 6.11 also reports the results for different types of insurance offered. The asset modelling capabilities of the surveyed companies offering accident & health insurance, and marine, aviation and transport insurance were relatively restricted, compared with those of the insurers offering other types of insurance. The surprising result is that none of the surveyed companies offering marine, aviation and transport insurance carried out asset modelling. Again this is perhaps because marine, aviation and transport insurance insurers only focused on underwriting operation and investment operation is largely ignored.

Table 6.11: The capability of asset modelling (Non-Life)

Capability	All	A&H	MAT	L	M	P	M&PL	O
Can project the total investment return	7 (47%)	1 (20%)	0 (0%)	1 (20%)	2 (40%)	3 (38%)	2 (29%)	2 (33%)
Assumptions can be varied from year to year	8 (53%)	1 (20%)	0 (0%)	2 (40%)	3 (60%)	4 (50%)	2 (29%)	2 (33%)
Can vary income and gains independently	4 (27%)	0 (0%)	0 (0%)	1 (20%)	1 (20%)	2 (25%)	1 (14%)	1 (17%)
Separate model points for different asset classes	4 (27%)	0 (0%)	0 (0%)	1 (20%)	0 (0%)	2 (25%)	1 (14%)	2 (33%)
Individual assets can be modelled	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Note:
All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned

Having considered the capability of asset modelling, it is also important to consider the liability modelling methods employed by the general insurance industry due to the importance of its loss experience on an insurer's results. Generally speaking, the liability process can be modelled at an individual level, or at an aggregated level. Modelling at the individual level is time-consuming and may not be feasible from a computation viewpoint. Nevertheless, this method allows modelling of the effects of the characteristics of individual liability (e.g. claim). In general no approximation is involved. By contrast, modelling at the aggregated level usually involves some approximation which, in many cases, is accurate enough.

Question nine asked how the liabilities were modelled within the organisations surveyed and the results are reported in Table 6.12. None of the non-life companies surveyed reported modelling their liabilities using policies individually. In fact, more than half of the respondents (58 per cent) modelled the liabilities using all or most in force policies in aggregate. In other words, most non-life companies surveyed modelled their liabilities using in force policies in aggregate instead of individually. This result is not surprising because it is not convenient for non-life insurance companies to handle large risk collectives consisting of individual risk units such as buildings in fire insurance and ships in marine insurance. Due to the nature of their products it would be inappropriate for non-life companies to model liabilities using policies individually. This is the reason why a collective approach without any regard to the individual risk units is commonly regarded as more satisfactory and is often employed in practice.

It is worth noting that the aggregate amount of claims is always one of the key concerns in the practical management of an insurance company. A stochastic aggregate claim amount model, where the number of claims and the size of each claim are generally stochastic, often applies particularly to non-life insurance classes. In other words, in non-life insurance the claim amount is usually assumed to be random rather than fixed.

In addition, one respondent reported using modelling points, which are commonly seen in the life insurance industry. The rest of the respondents who ticked the box for "other" used "*all in force policies split into homogeneous sub-groups*", "*incurred & paid claims & premiums*", "*all past and present policies individually*", or "*claims outstanding and incurred but not reported (IBNR) for short-tail business*". This suggests that the liability modelling methods in the non-life insurance industry were varied. Although modelling the liabilities using in force policies in aggregate seemed to be the standard practice in the industry, in some cases non-life insurers employed other approaches if need be.

Table 6.12: The method of liability modelling (Non-Life)

Method	All	A&H	MAT	L	M	P	M&PL	O
All in force policies individually	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Most in force policies individually	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
A sample of in force policies individually	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Modelling points	1 (8%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (12%)	1 (14%)	0 (0%)
All in force policies in aggregate	6 (50%)	3 (60%)	1 (50%)	2 (40%)	3 (60%)	3 (38%)	3 (43%)	3 (50%)
Most in force policies in aggregate	1 (8%)	0 (0%)	0 (0%)	1 (20%)	1 (20%)	1 (12%)	0 (0%)	13%
A sample of in force policies in aggregate	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Other	4 (33%)	2 (40%)	1 (50%)	2 (40%)	1 (20%)	3 (38%)	3 (43%)	3 (50%)

Note:
All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned

6. Forecast period

The length of forecast time horizon is vital in practical DFA applications. An analysis limited to a short time horizon may not completely reveal the long-term effects of adverse fluctuations and periodic variations of risk propensity. Nevertheless, as discussed in Chapter three the projection would become relatively unreliable as the projection period is lengthened. Therefore, the management of an insurance company should try to strike a balance between them.

In theory the horizon of business plan should be in general consistent with that of DFA to provide confidence in the DFA results. In order to investigate whether such a relationship existed in the non-life industry, respondents were asked about the length of the forecast (or projection) periods in DFA and in business plan respectively.

Table 6.13: The length of the forecast periods in DFA and BP (Non-Life)

Length of forecast period	All		A&H		MAT		L	
	DFA	BP	DFA	BP	DFA	BP	DFA	BP
1 year	3 (20%)	3 (20%)	1 (20%)	1 (20%)	1 (50%)	1 (50%)	1 (20%)	1 (20%)
2 years	0 (0%)	1 (7%)	0 (0%)	1 (20%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
3 years	5 (34%)	5 (34%)	2 (40%)	2 (40%)	1 (50%)	1 (50%)	4 (80%)	4 (80%)
4 years	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
5 years	3 (20%)	2 (13%)	1 (20%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
6~10 years	2 (13%)	2 (13%)	1 (20%)	1 (20%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
11~15 years	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
16~20 years	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
> 20 years	2 (13%)	2 (13%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Note:
1. All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned
2. DFA: Dynamic Financial Analysis; BP: Business Plan

Table 6.13: The length of the forecast periods in DFA and BP (Non-Life) (continued)

Length of forecast period	M		P		M&PL		O	
	DFA	BP	DFA	BP	DFA	BP	DFA	BP
1 year	1 (20%)	2 (40%)	1 (12%)	12%	2 (28%)	1 (14%)	2 (33%)	2 (33%)
2 years	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
3 years	2 (40%)	2 (40%)	5 (64%)	5 (64%)	4 (58%)	4 (58%)	2 (33%)	2 (33%)
4 years	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
5 years	2 (40%)	1 (20%)	0 (0%)	0 (0%)	0 (0%)	1 (14%)	0 (0%)	0 (0%)
6~10 years	0 (0%)	0 (0%)	2 (24%)	2 (24%)	1 (14%)	1 (14%)	0 (0%)	0 (0%)
11~15 years	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
16~20 years	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
> 20 years	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (34%)	2 (34%)

Note:
1. All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned
2. DFA: Dynamic Financial Analysis; BP: Business Plan

As evidenced in Table 6.13, the distributions of the length of the forecast periods in DFA and in business plan look similar. In order to give a formal indication of the correlation between the two, Kendall's tau-b and Spearman's rho correlation coefficients were calculated. The main reasons why two nonparametric methods were used are as follows. First, Kendall's tau-b and Spearman's rho are all suitable for ordinal data. Second, since each nonparametric method has its peculiar sensitivities and blind spots, it is always advisable to employ different methods with a view to double-checking the results. Thus, the two methods of calculating correlation coefficients were used.

The results for the surveyed companies as a whole and for those offering different types of insurance are summarised in Table 6.14. All correlation coefficients are statistically significant at the 0.05 level. This indicates that the null hypothesis of no relation between the forecast period in DFA and that in business plan can be rejected. These results confirm that in the general insurance industry the forecast period in DFA was correlated with that in the business plan.

In addition, in Table 6.13 the finding for the insurers offering liability insurance shows that the length of the forecast periods in DFA and business plan within these organisations was either one or three years. Since liability business is usually long-tail, this finding that a short time horizon was used by the companies seems somewhat unusual. An examination of these companies revealed that all of them offered not only liability insurance but other types of insurance such as property insurance. In other words, these firms were not specialist liability insurers. Moreover, the respondents were only allowed to tick one response to this question for DFA and business plan respectively. They might just choose the shortest time horizons employed in their practical applications. This is perhaps the main reason why these insurers reported using short time horizons.

Table 6.14: The correlation coefficient of the forecast periods (Non-Life)

Correlation Coefficient	All	A&H	MAT	L	M	P	M&PL	O
Kendall's tau-b	0.568**	0.652*	1.000**	1.000**	0.850**	1.000**	0.819*	1.000**
	[0.009]	[0.047]	[0.005]	[0.003]	[0.009]	[0.001]	[0.011]	[0.005]
Spearman's rho	0.666**	0.667*	1.000**	1.000**	0.946**	1.000**	0.841**	1.000**
	[0.004]	[0.049]	[0.000]	[0.000]	[0.000]	[0.000]	[0.004]	[0.000]

Note:
1. All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned
2. *Significant at the 0.05 level; **significant at the 0.01 level.
3. p values are in brackets.

In fact, 80 per cent of the respondents reported using the same length of forecasted period in DFA and in business plan. This is broadly in line with the evidence shown in Table 6.6 that 63 per cent of the respondents used DFA to help develop the business plan. Besides, 74 per cent reported employing forecast periods in both DFA and business plan of less than five years. This is consistent with the practice that the management of non-life insurance companies usually takes a relatively short-term view due to the volatile nature of non-life business.

Oakden, Friedland and Périgny (2001) also report that the length of projection period of Canadian property and casualty insurance and reinsurance companies was in line with that of the business plan. All companies' DCAT projection period and the projection period of 91 per cent of the companies' business plans were less than three years. Compared with UK general insurers, Canadian property and casualty insurance and reinsurance companies have relatively a short projection period. This is probably because the DCAT Standard of Practice suggests that the projection period for a typical property and casualty insurance company should be two fiscal years (Canadian Institute of Actuaries, 1998), whereas there is no similar rule or regulation for a non-life insurer in the UK.

7. Considerations of DFA results by senior management

It is widely accepted that the views of senior management concerning the importance of DFA determine how DFA is conducted within the organisation and whether the DFA results considerations are incorporated in their decision making processes. The more positive their views are, the more occasions these results are considered when a material decision is to be made. If these results proved useful and played an important role in the decision making, managers would pay more attention to employing DFA related techniques. In this case, the application of these techniques should afford business benefits.

Respondents were asked to indicate to what extent the senior management incorporated the DFA results considerations in their decision making processes. The results are summarised in Table 6.15.

Table 6.15: The incorporation of DFA results in decision making process (Non-Life)

Extent	All	A&H	MAT	L	M	P	M&PL	O
Always	2 (14%)	1 (20%)	0 (0%)	1 (20%)	0 (0%)	1 (14%)	1 (17%)	2 (33%)
Usually	5 (36%)	2 (40%)	0 (0%)	1 (20%)	1 (20%)	2 (29%)	2 (33%)	1 (17%)
Often	3 (21%)	0 (0%)	0 (0%)	1 (20%)	1 (20%)	1 (14%)	1 (17%)	1 (17%)
Occasionally	4 (29%)	2 (40%)	2 (100%)	2 (40%)	3 (60%)	3 (43%)	2 (33%)	2 (33%)
Never	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Note:
All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned

The above table shows a wide diversity in the extent to which the DFA results are incorporated in the decision making process by senior management. Half of the respondents indicated that the DFA result considerations are *always* or *usually* involved in the decisions made by senior management, whereas the other half *often* or *occasionally*. None of the respondents using DFA related techniques indicated such considerations were *never* made. This confirmed that all respondents took into account

DFA results obtained from their DFA exercises to a certain extent. One respondent further commented that "*in order to make sound judgement DFA results need to be looked at in their proper perspective*". This suggests that DFA is of help in this sense because it provides decision makers with some information which might be useful on financial condition of the company.

8. Difficulties experienced in communicating the DFA results to the Board

After investigating a number of issues on how DFA was used, the survey then sought to identify whether any difficulties have been experienced in communicating the DFA results to the Board of Directors. In Table 6.16 responses are presented ranked from the most common to the least common responses.

Communicating complex issues to non-specialists is the most common difficulty in reporting DFA results to the Board. More than half of the respondents (54 per cent) confirmed this fact. As previously mentioned, the results of DFA exercises using stochastic simulation in particular, often show very technical terms which are sometimes difficult to understand for management. If management could not appreciate DFA results and their importance, the DFA exercises would not be considered valuable. Therefore, how to efficiently and effectively communicate these results to non-specialists on the Board is the current focus of many actuaries charged with the DFA task.

One fifth of the respondents indicated that the Board expressed concern about the degree of conservatism in selecting adverse scenarios. As mentioned previously, the adverse scenarios considered in a DFA application should be plausible and possible. In particular they should reflect the external environment in which the company will operate. Determining the degree of conservatism in selecting adverse scenarios is in general based on professional judgement of the actuary. Generally speaking, this decision should be largely left with the actuary. After all, the actuary is employed to judge what is appropriate for the company in the particular circumstances in which it finds itself.

Lack of interest shown by members of the Board was recorded. This is partly because DFA results were not considered important by management, and may also be due to the fact that management has difficulty in understanding the results. Moreover, if non-life insurance companies were required by the regulator to employ DFA techniques to produce FCR, *lack of interest* would not be the difficulty in communicating the results to the Board.

Fourteen per cent of the respondents confirmed that it was difficult to present extremely adverse scenarios without causing undue concern while communicating DFA results to the Board. The decision whether an extremely adverse scenario is to be presented to the Board should be left with the actuary. If the actuary considers an extremely adverse scenario plausible it should be presented to the Board with detailed explanations in order not to cause undue concern. On the other hand, if an extremely adverse scenario is not likely to occur, it should not be presented to the Board in the first place.

Fourteen per cent of the respondents confirmed that members of the Board focused too much on assumptions rather than results. A respondent further commented that "*sometimes board members paid too much attention to the probability distributions assumed for a stochastic simulation analysis*". In general the actuary determines which probability distributions and associated parameters should be used. This decision is based on the actuary's experience and understanding of the risks faced by the company. Sometimes the decision is somewhat subjective. Views on assumptions could be varied. Board members should concentrate on examining the reasonableness of the results instead of going into too much detail on the assumptions.

A number of the respondents who ticked the box for "other" provided the following answers to this question. For example, "*directors may have different views on* *assumptions*" and "*directors do not understand the DFA results*". These responses have been discussed above. In addition, one respondent stated that no particular difficulties have been experienced.

Having examined the difficulties in communicating DFA results to the Board for the non-life respondents as a whole, the results for different types of insurance offered are also presented in Table 6.16 and discussed below. Communicating complex issues to non-specialists is the most common difficulty in reporting DFA results to the Board for all the different types of insurance. It is noted that 80 per cent of the respondents whose organisations offering liability insurance reported that they had difficulty in communicating complex issues to non-specialists. Why did such a high percentage of these respondents report having this difficulty? As noted earlier, liability insurance undertakes to assume the obligations imposed on the negligent party in the event of legal liability. It can be divided into three classes: employers' liability and workers compensation, automobile liability, and general liability. Since there is virtually no calculable limit to the losses that can arise from legal liability and the liability insurance business is in general long-tail, liability insurance is relatively complicated compared to other types of insurance. It is particularly the case for commercial liability insurance. Due to the complexity of issues it is relatively difficult for these respondents to effectively communicate the issues to non-specialists.

Table 6.16: Difficulties in communicating DFA results to the Board (Non-Life)

Difficulty	All	A&H	MAT	L	M	P	M&PL	O
Difficulties in communicating complex issues to non-specialists	8 (54%)	3 (60%)	1 (50%)	4 (80%)	3 (60%)	5 (63%)	3 (43%)	3 (50%)
Concern regarding the degree of conservatism in selecting adverse scenarios	3 (20%)	1 (20%)	0 (0%)	2 (40%)	1 (20%)	3 (38%)	1 (14%)	1 (17%)
Other	3 (20%)	0 (0%)	0 (0%)	0 (0%)	1 (20%)	1 (13%)	1 (14%)	1 (17%)
Lack of interest	2 (14%)	2 (40%)	1 (50%)	1 (20%)	1 (20%)	2 (25%)	2 (29%)	1 (17%)
How to present extremely adverse scenarios without causing undue concern	2 (14%)	1 (20%)	0 (0%)	2 (40%)	2 (40%)	2 (25%)	1 (14%)	1 (17%)
Too much focus on assumptions rather than results	2 (14%)	1 (20%)	0 (0%)	0 (0%)	0 (0%)	1 (13%)	2 (29%)	0 (0%)

Note:
All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned

9. Main reasons for not using the DFA related techniques

The final question in Part A of the questionnaire was directed at those organisations who did not use any of the DFA related techniques. The organisations were asked about the main reasons for not using these techniques. The results are summarised in Table 6.17. The most striking result is that 76 per cent of the respondents indicated that *lack of need* is the main reason for not using these techniques. However, the FSA has proposed changes to insurance regulation indicating that risk-based approaches will be adopted. Although the proposals do not prescribe a particular approach, DFA would obviously be useful. Thus, organisations not using DFA now will probably be doing something along the lines of DFA in the future. That is, regulatory changes will inevitably force insurance companies to adopt DFA at some point in the future.

As will be shown in the next section, the response rate of the non-life postal survey (36 per cent) was much lower than that of the life postal survey (76 per cent). The relatively low response rate of the non-life survey suggests a relatively low level of practitioner interest in the subject of DFA/FCR. *Lack of need* might be the reason behind this.

Lack of relevant knowledge and *lack of appropriate asset or liability models* were the second most common reasons. A number of respondents further commented that they wished to apply DFA techniques to their underwriting and/or investment operations, but they did not know how to do it. This finding suggests that there was a need to provide guidance on the use of DFA techniques for those who wished to conduct the relevant analyses. Several asserted that there was no appropriate asset or liability models which could meet their needs. They alluded to the fact that they were not able to modify the publicly available models and they could not develop their own models either. In this case, it seems that they had to resort to help of actuarial consultants.

Nineteen per cent of the respondents confirmed a lack of experience relative to the use of DFA techniques. An actuary alluded to the fact that the role of actuaries within his organisation was rather traditional. This confirms the popular belief that the areas in which actuaries are currently advising non-life companies mainly include determining the level of technical provisions needed for solvency and accounting purposes, and pricing non-life insurance products. This finding suggests that there was a need to encourage actuaries to be more involved with DFA exercises so that actuaries would learn by experience.

None of the respondents indicated that cost was the main reason. Nevertheless, using the DFA related techniques requires many resources, which are usually "expensive", such as people and technology. This will be further discussed in the next chapter of interview evidence.

The remaining responses were varied. Several respondents confirmed that they did not have actuarial resource at their disposal. This confirms the general view that the actuarial resource was scarce in most non-life companies. As will be stated in Section 7.5 of Chapter seven, only eight per cent of UK fellows work in the non-life insurance industry. In fact, many small non-life companies even did not have any actuaries within their organisations. This is probably because a statutory requirement for every UK non-life company to have an Appointed Actuary has not yet been introduced. In addition, one respondent commented that *"sophisticated analysis is not appropriate because of the nature of our risks"*. After examination of this company, it was a small captive insurer who only insures its parent company's property. Since the asset and liability structure of the company was simple, there was no need for the company to carry out complicated analyses.

The results for different types of insurance offered are also presented in Table 6.17. *Lack of need* is the main reason for not using the DFA related techniques for all types of insurance except marine, aviation and transport insurance. Two respondents whose organisations offered marine, aviation and transport insurance indicated that *lack of appropriate asset or liability models* is one of the main reasons for not using the techniques. In addition, three respondents gave other reasons which were not listed on the questionnaire. One respondent confirmed that these techniques were not used because *"the company was in run-off mode"*. Nevertheless, the techniques can still be employed for various purposes even when the company is in run-off. In fact, *lack of relevant knowledge* could be the reason why this company did not use these techniques. In addition, the remainder confirmed that the issue on the use of the techniques was *"not as high on list of priorities as other issues"*. Nevertheless, if changes in regulations force DFA on insurers then they will do it.

Table 6.17: Main reasons for not using the DFA related techniques (Non-Life)

Reason	All	A&H	MAT	L	M	P	M&PL	O
Lack of need	16 (76%)	8 (80%)	1 (33%)	3 (50%)	2 (50%)	8 (67%)	6 (67%)	2 (40%)
Lack of relevant knowledge	5 (24%)	2 (20%)	0 (0%)	3 (50%)	1 (25%)	3 (25%)	4 (44%)	0 (0%)
Lack of experience	4 (19%)	2 (20%)	0 (0%)	2 (33%)	1 (25%)	2 (17%)	3 (33%)	0 (0%)
Too expensive	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Lack of appropriate asset or liability models	5 (24%)	4 (40%)	2 (67%)	3 (50%)	2 (50%)	4 (33%)	4 (44%)	1 (20%)
Other	6 (29%)	4 (40%)	3 (100%)	2 (33%)	2 (50%)	5 (42%)	3 (33%)	3 (60%)

Note: All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned

10. Use of Financial Condition Report

Organisations participating in the survey were asked whether they produced FCR or its equivalent. Twenty seven per cent of the respondents indicated that FCR or its equivalent was produced within their organisations. Moreover, it is noted that 43 per cent of these respondents employing DFA techniques produced FCR. Because these techniques were normally used to derive the background information underlying the FCR, it would be interesting to identify differences in proportions of producing the FCR between the two groups, those who employed the techniques and those who did not. The Fisher's exact test was conducted, resulting in a p-value of 0.116. This indicates that we cannot reject the null hypothesis of no group difference in the proportions at the 0.05 level. This finding suggest that there is no relation between the use of the techniques and the production of FCR. This seems to imply that the use of these techniques was not necessarily intended for the production of the FCR. In other words, some other reports might be produced based on the results which were derived using the techniques.

Those who produced FCR were then asked how often the FCR was produced. Seventy eight per cent indicated that they produced FCR annually, with the remainder producing FCR on a monthly or quarterly basis. This finding seems to indicate that the frequency of producing FCR was varied in the non-life insurance industry, although most of the non-life companies did it annually.

The survey also asked the respondents who reported producing FCR within their organisations whether the FCR was available to their auditors and the FSA. All these respondents indicated that they made the FCR available to their auditors, whereas only 67 per cent the FSA. The respondents to this question were then requested to express their opinions regarding whether the FSA should have automatic access to the FCR. Forty three per cent indicated that the FSA should. Views were mixed on this issue on the automatic access. These respondents who were against the automatic access argued that the FSA may tend to react prematurely to the FCR which suggested some potential threat to the company's performance or solvency. In insolvency analysis it has been shown that premature intervention against a financially weak but still solvent insurance firm might lead to it becoming insolvent. This result is very likely to occur if the news of intervention is made public and damage the insurer's ability to take measures to improve its financial strength. Nonetheless, if the FSA delays taking action against weak firms, some insolvencies which could be preventable may occur in the end. It is difficult to balance the risk of premature action and excessive forbearance in practice. On the whole, the comments volunteered by the survey respondents suggest that UK Chief Actuaries and Finance Directors remained concerned with the release of the FCR. Furthermore, in a number of cases the respondents appeared to be more concerned with the misinterpretation of financial statements by the general public than with the premature action by the FSA.

As previously stated, GN2 is a Guidance Note produced by the Faculty and Institute of Actuaries to help actuaries produce FCR. However, there is currently no similar Guidance Note on FCR specifically for non-life insurance companies. The survey respondents were asked whether it is necessary to introduce such a Guidance Note. Forty four per cent of the respondents indicated that a Guidance Note on FCR for non-life insurance companies is necessary. Those who indicated that such a Guidance Note should be introduced were then asked what classification they would like the Guidance Note to have. Seventy five per cent indicated that the Guidance Note should be initially standard practice, whereas the rest considers it should be mandatory. These results show that views on whether the Guidance Note should be introduced differ. Some respondents expressed concern about the impact of the introduction of such a Guidance Note on their authority. The following quotation, from the Chief Actuary of a multi-line general insurer, is indicative of the concern of these respondents.

"If it [Guidance Note] is introduced actuaries would like to be left with complete discretion and should be able to do whatever is necessary for their companies based on their professional judgement."

This quotation suggests that the large proportion of the respondents reporting concern over the introduction of such a Guidance Note may be due to a reluctance to give up their complete discretion. Therefore, if this concern can be properly addressed, the proposal for the new Guidance Note would receive a generally favourable reaction.

Respondents who did not produce FCR were asked the main reasons for not producing it or its equivalent. The results are reported in Table 6.18. Eighty three per cent of the respondents indicated that *lack of need* is the main common reason why FCR was not produced. As evidenced previously, this is also the main reason why the DFA related techniques were not used. *Lack of relevant knowledge* and *lack of experience* are the second and third most common reasons. Again, none of the respondents indicated that cost is the main reason. Other reasons provided by some respondents include "*lack of actuarial resource*" and "*don't know what it is*", etc.

The results for different types of insurance offered are also presented in Table 6.18. All the respondents whose organisations offered marine, aviation and transport insurance, liability insurance, motor insurance, and miscellaneous and pecuniary loss insurance indicated that *lack of need* was one of the main reasons for not producing FCR. It is also noted that this was the only reason indicated by the respondents from companies offering marine, aviation and transport insurance, and motor insurance. A number of respondents emphasised that while their company did not produce FCR, they carried out similar financial analyses and presented the results in different reports. For example, the finance director from a specialist motor insurer commented that:

"There is no need to produce FCR. We have other reports covering similar things. We analyse the financial condition of the company on a regular basis."

The respondent who made the above comment employed two DFA techniques, including sensitivity testing and scenario testing. This finding suggests that in non-life insurance these techniques were not necessarily used to derive the background information underlying the FCR.

Due to the small sample size in the non-life study, it was a difficult, if not impossible, task to examine the relations resulting from a particular type of business. Moreover, there are very few specialist general insurers in the UK and their historical data are sometimes unavailable. If more data for specialist general insurers become available, these relations would be relatively easily identified.

Table 6.18: Main reasons for not producing FCR (Non-Life)

Reason	All	A&H	MAT	L	M	P	M&PL	O
Lack of need	20 (83%)	9 (82%)	3 (100%)	4 (100%)	5 (100%)	8 (89%)	7 (100%)	5 (71%)
Lack of relevant knowledge	4 (17%)	3 (27%)	0%	1 (25%)	0%	1 (11%)	2 (29%)	0%
Lack of experience	3 (13%)	2 (18%)	0%	1 (25%)	0%	1 (11%)	2 (29%)	0%
Lack of guidance	2 (8%)	2 (18%)	0%	1 (25%)	0%	1 (11%)	1 (14%)	0%
Too expensive	0 (0%)	0%	0%	0%	0%	0%	0%	0%
Other	3 (13%)	1 (9%)	0%	0%	0%	1 (11%)	0%	2 (29%)

Note:
All: all companies; A&H: companies offering accident & health insurance; MAT: companies offering marine, aviation and transport insurance; L: companies offering liability insurance; M: companies offering motor insurance; P: companies offering property insurance; M&PL: companies offering miscellaneous & pecuniary loss insurance; O: companies offering insurance except the above-mentioned

6.3 The Current Practice of the Life Insurance Industry

It should be pointed out that with a view to drawing a comparison between the practices of non-life companies and those of life offices, the section largely mirrors the non-life group. Several statistical tests that have been carried out in the previous section are repeated. However, in this section the details of the same tests are not given again in order to economise on duplication.

6.3.1 The Main Survey

As outlined within the research methods chapter, the life survey population is identified as the companies included in the SynThesys Life. Ninety two organisations received a postal survey during May 2002. Ten offices were randomly selected for pilot testing the questionnaire. Hence, there were 82 organisations contacted in the main survey. Of the 82 companies, 62 responded, representing a response rate of 76 per cent. Of the 62, four responded in writing confirming that they would not be completing the questionnaire. Of the four, two stated that their business have been transferred to another company. One indicated that he was unable to complete the questionnaire owing to very heavy pressure of work. The other one stated that he was no longer the Appointed Actuary of the company. This yielded an overall total of 58 usable responses from a population of 82, giving a usable response rate of 71 per cent. The high response rate suggests a high level of practitioner interest in the subject of DST/FCR.

6.3.2 The Non-Respondent Bias

The profile of those who responded was examined in order to determine whether or not it was a representative sample of the whole population. As in the previous section, three financial characteristics were chosen to investigate whether or not the non-respondent bias existed in the life survey. The first two financial characteristics selected were the same ones as those used in the non-life analysis. The last financial characteristic, the average net premiums written was replaced by the average net premiums earned due to the availability of data. The required data were also obtained from the SynThesys Life for the years 1996-1999.

Similarly, Levene's test for equality of variances was conducted for the above-mentioned financial characteristics using a significant level of 0.05. Table 6.19 presents the statistical results.

Table 6.19: Levene's test for the financial characteristics (Life)

Financial characteristic	F	P-value	Decision (α=0.05)
Average net admissible assets	5.406	0.023	Reject H_o
Average profit before tax	5.173	0.026	Reject H_o
Average net premiums earned	0.142	0.707	H_o cannot be rejected

The results presented in the above table show that we can reject the null hypothesis at the 0.05 level that the financial characteristics of the respondent and non-respondent groups have equal variances for the average net admissible assets and average profit before tax, but cannot reject it for the average net premiums earned. Consequently, these two groups were assumed to have unequal variances in terms of the average net admissible assets and average net profit before tax. Nevertheless, it seems that these two groups have equal variances in terms of the average net premiums earned.

Independent-samples two-tailed t tests were conducted for the three financial characteristics based on the above-mentioned variance assumptions. Table 6.20 presents the results, showing that we cannot reject the null hypothesis at the 0.05 level that the means of the average profit before tax and average net premiums earned of the survey respondents were equal to those of the survey non-respondents, but can reject it for the average net admissible assets.

Table 6.20: Independent-samples t test for the non-respondent bias (Life)

Financial characteristic	Survey respondent (£000)	Survey Non-respondent (£000)	t (p-value)	Decision (α=0.05)
Average net admissible assets	92,924	17,253	2.339 (0.023)	Reject H_o
Average profit before tax	27,738	2,549	1.758 (0.085)	H_o cannot be rejected
Average net premiums earned	575,638	563,148	0.042 (0.966)	H_o cannot be rejected

Given the high response rate which was achieved in the life postal survey, it was unusual to reject the null hypothesis that the mean of the net admissible assets of the survey respondents was equal to that of the survey non-respondents. After careful investigation of the respondent group, it was found that there were three large organisations with "extraordinary" average net admissible assets. The values for the net admissible assets of these companies were £1,226m, £685m, and £492m. The group of non-respondents did not consist of any organisations with average net admissible assets of this magnitude. If these three organisations were removed from the group of respondents, the results for the Levene's test and independent-samples t test were shown in Tables 6.21 and 6.22.

Table 6.21: Levene's test for the average net admissible assets (Life)

Financial characteristic	F	P-value	Decision (α=0.05)
Average net admissible assets	3.857	0.054	H_o cannot be rejected

Table 6.22: Independent-samples t test for the non-respondent bias in terms of the average net admissible assets (Life)

Financial characteristic	Survey respondent (£000)	Survey Non-respondent (£000)	t (p-value)	Decision (α=0.05)
Average net admissible assets	45,712	17,253	1.162 (0.250)	H_o cannot be rejected

After these three organisations were removed, the hypothesis that the mean of the net admissible assets of the survey respondents was equal to that of the non-respondents cannot be rejected. Based on the overall results, the respondent sample is considered to be a representative sample of the survey population in terms of these financial characteristics.

6.3.3 Survey Results

This section reports the survey findings of the DST/FCR practices in the life insurance industry. As stated in Chapter two, two similar surveys have been carried out. The first survey was undertaken by the Dynamic Solvency Testing Working Party (1994) with a view to drafting guidance for Appointed Actuaries on FCR. After GN2 was formally introduced into the solvency monitoring process in 1996, the second survey was administered by Muir and Sarjant (1997) in order to investigate a number of practical issues associated with DST/FCR. The key findings that resulted from the present survey analysis are now presented grouped by topic, and where appropriate are considered relative to the existing literature and survey findings, including the non-life survey results presented in the preceding section. Again, it should be noted that the comparison between the above-mentioned studies should be treated with caution because the nature of the business of the sampled companies is different. In the report by the Dynamic Solvency Testing Working Party (1994), 29 with-profit offices were analysed. In the survey by Muir and Sarjant (1997), 49 responses were received including replies from 31 with-profit offices. In the non-life survey of the thesis, 34 usable responses were obtained from insurance companies carrying on non-life business.

The respondents were also asked at the end of the questionnaire about what kind of insurance policies their offices sold. Five classes of business were listed. Since most of life offices offered more than one type of insurance contract, respondents were allowed to tick more than one response to this question.

Table 6.23: The class of business (Life)

Class of business	Number (percentage) of respondents
Non-linked contracts (other than with-profit policies)	47 (81%)
Accumulating with-profit policies	36 (62%)
Property linked contracts	47 (80%)
Index linked contracts	30 (52%)
Other	12 (21%)

Table 6.23 presents the results. Eighty one per cent of the respondents reported selling non-linked contracts (other than with-profit policies). Eighty per cent of the respondents indicated that property linked contracts were sold within their organisations, whereas 52 percent index linked contracts. A further examination of these companies revealed that 50 per cent of the surveyed life offices sold both property and index linked contracts, and that 83 per cent either property or index linked contracts. Ninety seven per cent of the offices offering index linked contracts also sold property linked contracts, whereas

62 per cent of the offices offering property linked contracts also sold index linked contracts. This is generally representative of the whole life insurance market in which the number of the companies offering property linked contracts is greater than that of the companies offering index linked contracts. A number of the respondents ticking "*other*" reported selling "*financial reinsurance contracts*", "*group and individual income protection insurance contracts*", "*group life insurance contracts*", etc.

As stated previously, 58 usable responses, in total, were obtained in the life survey. In this thesis, an office offering accumulating with-profit policies is defined as a with-profit office. According to this definition, there were 36 with-profit and 22 non-profit offices responded to this survey. The replies from with-profit offices accounted for 62 per cent of the responses. As stated in Chapter two, the nature of with-profit and non-profit businesses is different. The former allows the policyholder to participate in the profits earned by the fund, whereas the latter does not. Due to this significant difference the DST/FCR practices within with-profit and non-profit offices might be different. A number of analyses by the type of business written will be conducted to investigate whether there is any differentiation between the two.

An examination of the replies from non-profit offices revealed that 82 per cent of them involved unit-linked business, whereas 18 per cent only sold non-linked contracts (other than with-profit contracts). These contracts include conventional annuities and term life cover, etc. Since most of the non-profit offices involved unit-linked business, and with-profit and unit-linked policies have different characteristics, the comparison made in this thesis between with-profit and non-profit businesses can be regarded as in some cases the comparison between with-profit and unit-linked businesses.

1. Use of DST related techniques

Table 6.24 reports the use of the DST related techniques within life offices, including sensitivity testing, scenario testing and stochastic simulation. Scenario testing was the most commonly used DST technique and nearly 80 per cent of the organisations surveyed reported using it when conducting DST. Seventy six per cent indicated that they carried out sensitivity testing, whereas 36 per cent stochastic simulation. Only six respondents (10 per cent) reported that none of the techniques was used within their organisations. A number of additional comments were volunteered by these respondents. For example, one Appointed Actuary commented:

"*Our current practice, as described in this survey, is under review. In the future we expect to complete FCR on an annual basis in line with GN2 and meet regulatory requirements. We are currently developing modelling capabilities to allow us to complete solvency testing. Initially we will concentrate on projecting the solvency position over a ten-year period using sensitivity and scenario testing.*"

Another Appointed Actuary stated that some basic analyses were conducted within the organisation:

"*Although we do not use any of these (DST related) techniques, we do analyse the sensitivity of the business to a range of factors.*"

These additional comments suggest that for a number of organisations reporting not using any of the DST techniques, they are developing their capabilities of using these techniques or are doing something along the lines of DST.

Table 6.24: The use of DST related techniques (Life)

DST technique	All	With-profit	Non-profit	p-value Fisher's exact test
Sensitivity testing	44 (76%)	30 (83%)	14 (64%)	0.118
Scenario testing	46 (79%)	34 (94%)	12 (55%)	0.000**
Stochastic simulation	21 (36%)	20 (56%)	1 (5%)	0.000**
None of the above	6 (10%)	1 (3%)	5 (23%)	0.025*

Note: *significant at the 0.05 level; **significant at the 0.01 level.

Table 6.24 also shows that there is a big difference between with-profit and non-profit offices in terms of the DST techniques used. Apparently the percentages of using these techniques within with-profit offices were higher than those of using these techniques within non-profit offices. In order to formally confirm this, the Fisher's exact test was conducted to determine whether there is a relation between the type of business written ("With-profit (Code=1)" and "Non-profit (Code=2)") and each of the DST techniques used ("Yes (Code=1)" and "No (Code=2)"). The p-values obtained from the Fisher's exact test were all less than 0.05 except the one for sensitivity testing. This indicates that the null hypotheses between the type of business written and each of the DST techniques except sensitivity testing can be rejected at the 0.05 level. The conclusion is that the proportions of the use of scenario testing and stochastic simulation within with-profit and non-profit offices differ. In addition, the proportion of not using any of the techniques also statistically differs between them (p-value = 0.025). Two observations can be made from the results. First, approximately all the surveyed with-profit offices used at least one of the techniques, whereas five non-profit respondents (23 per cent) did not use any of them. Second, the use of relatively advanced financial modelling techniques was more common within with-profit offices than non-profit offices. These findings seem to suggest that with-profit offices were more capable of using financial modelling techniques than their non-profit counterparts. One of the possible reasons behind this is that with-profit policies typically involve guarantees and complicated investment operations are accordingly required. By contrast, non-profit offices usually do not provide a guaranteed return.

Besides, it is noted that the proportion of the life offices surveyed using the financial modelling techniques (90 per cent) was significantly higher than that of their non-life counterparts (41 per cent). Again this is probably because investment operations are complicated in life insurance compared to general insurance. In general, it is essential to employ relatively advanced financial modelling techniques in complicated investment operations.

The percentages of the organisations using sensitivity testing (76 per cent) and scenario testing (79 per cent) are higher than those reported in the Dynamic Solvency Testing Working Party (1994). In the survey conducted by the Working Party, 72 per cent of with-profit offices reported using sensitivity testing and 59 per cent scenario testing. The comparison of the findings of the present survey and those reported by the Working Party indicates that the overall use of financial modelling techniques has been greatly improved over the years. Although the use of stochastic simulation was not investigated in the report by the Working Party, it is believed that at present more life offices employ this techniques than in the past.

The results of the number of DST related techniques used by the responding organisations are summarised in Table 6.25. It shows that 28 per cent of the respondents employed all these three techniques. Forty seven per cent used two of these techniques, while 15 per cent only used one. Compared to the non-life results in Table 6.4, it is obvious that the use of these techniques were more common in life insurance than in general insurance.

Table 6.25: The number of DST related techniques used (Life)

Number of DST techniques used	All	With-profit	Non-profit
0	6 (10%)	1 (3%)	5 (23%)
1	9 (15%)	2 (6%)	7 (32%)
2	27 (47%)	17 (47%)	10 (45%)
3	16 (28%)	16 (44%)	0 (0%)

It is interesting to note that 56 per cent of the organisations using one technique employed sensitivity testing, whereas 44 per cent of these organisations conducted scenario testing. None of them only used stochastic simulation. Moreover, 81 per cent of the organisations using two techniques employed sensitivity testing and scenario testing, while 15 per cent scenario testing and stochastic simulation. Only 4 per cent used sensitivity testing and stochastic simulation. There are three possible reasons behind this. The first is that a "technical gap" between scenario testing and stochastic simulation seemed to exist in the life sector as well. The second possible reason is that for some life insurance firms they may simply believe that scenario testing can better serve their purposes. Finally, the difference between scenario testing and stochastic simulation is mainly concerned with the freedom of selection. It may be because practitioners conducting scenario testing are confident of their professional judgement on selection of variables and their associated values.

Table 6.25 also reports the results for with-profit and non-profit offices respectively. Forty four per cent of the surveyed with-profit offices employed all of these three techniques, while none of the surveyed non-profit offices did. It is also noted that only nine per cent of the with-profit offices used one or none of the techniques, whereas 55 per cent of the non-profit offices did. These findings again seem to suggest that with-profit offices were more capable of employing these techniques than their non-profit counterparts. This is possibly because with-profit offices had relatively complicated business. Therefore, they required more advanced techniques to meet their needs.

2. Application of DST related techniques

The survey respondents were asked what the applications of the DST related techniques were within their companies. The results are shown in Table 6.26. It is clear that the applications were more extensive within with-profit offices than within non-profit offices. It is hardly surprising that approximately all of the surveyed with-profit and non-profit offices employed DST techniques for solvency testing purposes. This is because under GN2 the DST techniques were originally introduced into the solvency monitoring process and as a result, Appointed Actuaries were relatively familiar with this application. In addition, since GN2 was more relevant to with-profit business than to non-profit business, non-profit offices were relatively reluctant to comply with it. This will be further confirmed by one of the interviewees from a unit-linked office.

Again the Fisher's exact test was conducted to determine whether there is a relation between the type of business written and each of the applications. The p-values for *capital allocation* and *asset allocation* were 0.006 and 0.000 respectively. This indicates that the null hypotheses between the type of business written and *capital allocation*, and between the type of business written and *asset allocation* can be rejected at the 0.01 level. One conclusion can be drawn from the results. The proportions of applying the techniques to *capital allocation* and *asset allocation* within with-profit and non-profit offices differ. Due to the nature of their business non-profit offices paid relatively little attention to these two areas compared to their with-profit counterparts.

Compared with the non-life results reported in Table 6.6, there are several differences between the two. First, 98 per cent of the life offices surveyed reported applying these techniques to solvency testing, whereas only 57 per cent of the respondents in the non-life survey did. This is probably because under GN2 life offices are encouraged to investigate their solvency position using these techniques. Second, the results of the life survey indicate that the other main applications were capital allocation (40 per cent), asset allocation (40 per cent), and development of business plan (35 per cent), whereas those of the non-life survey were evaluation of reinsurance programmes (64 per cent), development of business plan (63 per cent), and pricing (51 per cent). This suggests that life offices were relatively focused on investment operation, while non-life companies on underwriting operation. Third, a number of life offices communicated the DST results with rating agencies to show their understanding of the risks they faced (12 per cent) and were able to apply these techniques to surplus allocation (10 per cent), whereas no respondents in the non-life survey reported such applications. Generally speaking, it is hardly surprising that none of the non-life and non-profit respondents reported using the techniques for surplus allocation purposes. This is possibly because how to allocate surplus is not a main issue within their organisations. Nevertheless, it is a pity that none of them communicated the DST/DFA results with rating agencies. Since in the insurance industry the techniques were mainly used for solvency testing purposes, insurance companies should make good use of the results to show their rating agencies their understanding of risk exposures. In addition, other applications which were reported by these life offices surveyed included "*future embedded values*" and "*profitability*".

Table 6.26: The application of DST related techniques used (Life)

Application of DST techniques	All	With-profit	Non-profit	p-value Fisher's exact test
Solvency testing	51 (98%)	35 (100%)	16 (94%)	0.327
Capital allocation	21 (40%)	19 (54%)	2 (12%)	0.006**
Evaluate reinsurance programmes	6 (12%)	5 (14%)	1 (6%)	0.650
Help develop business plan	18 (35%)	14 (40%)	4 (24%)	0.354
Pricing	14 (27%)	8 (23%)	6 (35%)	0.506
Asset allocation	21 (40%)	21 (60%)	0 (0%)	0.000**
Surplus allocation	5 (10%)	5 (14%)	0 (0%)	0.159
Evaluate merger and acquisition	4 (8%)	3 (9%)	1 (6%)	1.000
Communicate the results with rating agencies	6 (12%)	6 (17%)	0 (0%)	0.161
Other	1 (2%)	0 (0%)	1 (6%)	0.327

Note: *significant at the 0.05 level; **significant at the 0.01 level.

3. Scenario testing related issues

Eighty nine per cent of the life offices surveyed indicated that they regularly run less than ten scenarios in scenario testing, whereas 11 per cent reported using 11-20 scenarios. These results were consistent with the non-life results presented in the preceding section. It seems that life offices did not run more scenarios than their non-life counterparts.

As to the frequency of scenario testing, the results are summarised in Table 6.27. Sixty one per cent of the life offices surveyed reported conducting scenario tests on a yearly basis. No life office reported doing the tests daily, but one weekly. The Appointed Actuary of that life office commented on the questionnaire:

"*We do the testing when we need it. On average, we do it weekly.*"

It should be noted that on a relatively frequent basis life offices might conduct scenario testing of some factors of which they are extremely susceptible. For example, one Appointed Actuary ticking "other" as the response to the question commented:

"*We do all areas annually, but key areas monthly.*"

Another Appointed Actuary ticking "other" stated:

"*At early stages of development, frequency will be at least annually but probably more often.*"

In addition, it seems that life offices implemented scenario tests less frequently than their non-life counterparts. As mentioned above, 61 per cent of the life offices surveyed reported implementing scenario tests annually. However, only 17 per cent of the non-life companies surveyed reported conducting the tests annually and the rest of the companies conducted on a more frequent basis. This may be due to the different nature of business in general and life insurance. For life insurance companies, the major uncertainty is inherent in the timing of future liability payments. For instance, policyholders and annuitants have a variety of options such as policy loan and surrender options whose relatively unpredictable exercise can have an impact on a life office's financial results. For general insurers, the uncertainties loom larger. They are in inherent in not only the timing but also the magnitude of liabilities. The magnitude of non-life liabilities is more unpredictable than that of life liabilities is because of the principle of indemnity. In general insurance, the insured is entitled to payment from the insurance company only if he or she has suffered a loss and only to the extent of the financial loss sustained. The attempt is made to put the insured back in exactly the same financial position after a loss as before the loss and accordingly the claim payment is not certain at the inception of the non-life policy. By contrast, the principle of indemnity applies on a modified basis in the case life insurance. In most cases, the claim payment is fixed since the life policy's inception. From the above discussions, it is obvious that non-life business generally is more volatile than life business. Therefore, it is necessary for the non-life companies to conduct these tests relatively frequently.

Table 6.27: The frequency of scenario tests conducted (Life)

Frequency	All	With-profit	Non-profit
Daily	0 (0%)	0 (0%)	0 (0%)
Weekly	1 (1%)	1 (3%)	0 (0%)
Monthly	3 (7%)	3 (9%)	0 (0%)
Quarterly	6 (13%)	3 (9%)	3 (23%)
Half yearly	4 (9%)	2 (6%)	2 (15%)
Annually	28 (61%)	20 (61%)	8 (62%)
Other	4 (9%)	4 (12%)	0 (0%)

Question five listed 24 risk categories and asked the respondents conducting scenario tests whether assumptions relating to any of these risk categories were varied in the scenarios. The responses obtained to this question are shown in Table 6.28. These results show that on average more than 80 per cent of the life offices surveyed tested variations in the assumptions of *future investment conditions*, *levels of new business*, *expenses*, and *persistency*. Because investments generate a significant part of their income, all offices employing scenario testing varied assumptions about *future investment conditions*.

Experience has indicated that a very high portion of a life office's expenses originates with the cost of writing new or renewal contracts. Since the commissions and other initial expenses together with the required contribution to reserves exceed the first-year premium, the sale of a new policy generally results in a reduction in shareholders' funds. In other words, the *shareholders funds* of a life office is subject to a drain during periods of increasing sales. If the level of new business is increased to a large extent during a short period, it would cause deterioration in the adequacy of shareholders' funds, and the solvency of the office would be seriously impaired. Moreover, according to the industry's experience analyses, the experience of newly acquired business is significantly different from that of seasoned business. This difference could be critical for insurers whose books are changing rapidly. Therefore, most life offices considered the two risk categories *levels of new business* and *expenses* important and included them in scenarios.

Even though life offices front-end load expense charges, they generally experience a net loss on policies that were surrendered early. For the offices which compensate for high first-year policy expenses through a modified reserving system, the company would recover even less of its costs from policies that lapse within a few years of issue. This is perhaps the reason why the assumption concerning *persistency* was tested.

The above-mentioned four risk categories were included in scenario tests because of their importance to company performance. Perhaps a more important reason for including them is that under GN2 these four assumptions should be tested unless there are any specific reasons for not doing so.

GN2 also lists a number of assumptions which may be of considerable importance to some companies but not others. These are *allocation of profit*, *mortality and morbidity*, *taxation*, *exercising of options by policyholders*, *exercising of options by the company*, *effects of asset-defaults*, *unit pricing bases*, and *risk of reinsurer default*. These risk categories were rarely seen in the scenarios used by the life offices surveyed except *mortality and morbidity* (67 per cent), *exercising of options by policyholders* (30 per cent), and *allocation of profit* (20 per cent). Other assumptions which were tested by more than half of the life offices surveyed included *equity returns* (89 per cent), *interest rate level* (78 per cent), *deterioration of asset values* (70 per cent), *asset mix* (65 per cent), *bonus rate* (61 per cent), and *premium volume* (59 per cent). Leverage and liquidity risks are common risks, but no life offices surveyed included them in the scenarios.

In order to determine whether there is any differentiation between with-profit and non-profit offices in terms of the risk categories included in scenarios, the Fisher's exact test was performed due to small sample size. Again the "No" category was merged with the "N/A" category. There are four risk categories whose p-values obtained from the Fisher's exact test are less than 0.05, including *allocation of profit*, *equity returns*, *asset mix* and *bonus rate*. They will be discussed below.

It is noted that none of the non-profit offices included *allocation of profit* as one of the scenarios, while 27 per cent of with-profit offices did. The p-value obtained from the Fisher's exact test is 0.044. This indicates that the null hypothesis of no relation between the type of business written and the inclusion of this risk category can be rejected at the 0.05 level. This suggests that the proportions of the inclusion of the risk category within the two groups differ. In the UK, the directors of insurance companies decide on the allocation of profit between policyholders and shareholders, and between different cohorts and types of policies. The directors are required to receive a report from the Appointed Actuary before the decision is made. In contrast, unit-linked policies, for example, in general enjoy a high degree of transparency in terms of profit allocation, in particular when compared to with-profit policies. The reason why with-profit offices tended to include *allocation of profit* in scenarios while their non-profit counterparts did not, is because in with-profit business the allocation of profit is mainly subject to offices, whereas it is not in non-profit business.

Since UK life insurance firms have always invested a large portion of their assets in equities, equity returns play an important role in the investment performance of life offices. In the life survey, all with-profit offices included the risk category *equity returns* in scenarios, whereas only 62 per cent of the non-profit offices did. Thirty eight per cent of them did not either include this risk category or consider it applicable. A p-value of 0.001 was obtained from the Fisher's exact test, which suggests that the difference in the proportions within the two groups is statistically significant at the 0.01 level. A further examination of the non-profit offices which did not include *equity* *returns* in scenarios or that considered it inapplicable revealed that most of them simply did not have much exposure to the fluctuations in the stock market. Nonetheless, it is worth emphasising that this finding does not imply that the return on equities is not important to non-profit offices. In fact, a very significant proportion of the unit-linked assets are invested in equities. Any sharp fluctuations in the value of equities could result in a drop in the sales of unit-linked policies and accordingly the asset management fee income and premium income would be adversely affected. In general sharp stock market fluctuations may lead to volatile performance of unit-linked offices.

It is clear that investment operation is important for life offices. This is because the return earned on investment is an important variable in the rating process of life offices and they assume some minimum rate of interest earnings in their rate calculations. In order to obtain good returns on investments, life offices have to pay particular attention to asset structure. The results show that only eight per cent of the non-profit offices reported including *asset mix* in scenarios. A p-value of 0.000 was obtained, which indicates that we can reject the null hypothesis of no relation between the type of business written and the inclusion of *asset mix*. This finding therefore provides support for the view that with-profit offices are more likely to include this risk category than their non-profit counterparts. This is because in with-profit business the decision on asset allocation is left to the office, whereas in unit-linked business, for example, the policyholder can determine the asset categories in which premiums are invested.

In with-profit insurance the premium bases normally are assessed based on extremely conservative assumptions. Therefore with-profit business in general generates profits. Some of them will be given back to policyholders in the form of bonuses. Nevertheless, if a great deal of profit is distributed or allocated to guaranteed bonuses requiring technical reserves to be established, the solvency position of the company may be seriously damaged. As a result it is hardly surprising that *bonus rate* was included in scenarios by more than 80 per cent of the surveyed with-profit offices. In non-profit insurance policyholders are not allowed to participate in the profits earned by the fund.

However, the changes of the benefit sums of linked contracts are sometimes regarded as bonuses. This is possibly the reason why eight per cent of the surveyed non-profit offices also reported including it in scenarios. The associated p-value is 0.000. This suggests that there is a strong relationship between the type of business written and the inclusion of *bonus rate*. This is in line with the view that with-profit offices are more likely to include this risk category than their non-profit counterparts.

Table 6.28: The risk category included in scenarios (Life)

Risk category	All			With-profit			Non-profit		
	Yes	No	N/A	Yes	No	N/A	Yes	No	N/A
Future investment conditions	46 (100%)	0 (0%)	0 (0%)	33 (100%)	0 (0%)	0 (0%)	13 (100%)	0 (0%)	0 (0%)
Levels of new business	37 (80%)	5 (11%)	4 (9%)	28 (85%)	3 (9%)	2 (6%)	9 (68%)	2 (16%)	2 (16%)
Expenses	36 (78%)	8 (17%)	2 (5%)	26 (79%)	6 (18%)	1 (3%)	10 (77%)	2 (15%)	1 (8%)
Persistency	35 (76%)	8 (17%)	3 (7%)	26 (79%)	7 (21%)	0 (0%)	9 (69%)	1 (8%)	3 (23%)
Allocation of profit*	9 (20%)	23 (50%)	14 (30%)	9 (27%)	17 (52%)	7 (21%)	0 (0%)	6 (46%)	7 (54%)
Mortality and morbidity	31 (67%)	12 (26%)	3 (7%)	23 (70%)	9 (27%)	1 (3%)	8 (62%)	3 (23%)	2 (15%)
Taxation	3 (7%)	37 (80%)	6 (13%)	0 (0%)	28 (84%)	5 (16%)	3 (23%)	9 (69%)	1 (8%)
Exercising of options by policyholders	14 (30%)	50%	9 (20%)	12 (36%)	16 (49%)	5 (15%)	2 (15%)	7 (54%)	4 (31%)
Exercising of options by the company	4 (9%)	23 (65%)	12 (26%)	4 (12%)	21 (64%)	8 (24%)	0 (0%)	9 (69%)	4 (31%)
Effects of asset-default	5 (11%)	30 (72%)	8 (17%)	4 (12%)	24 (73%)	5 (15%)	1 (8%)	9 (69%)	3 (23%)
Unit pricing bases	1 (2%)	33 (76%)	10 (22%)	1 (3%)	26 (79%)	6 (18%)	0 (0%)	9 (69%)	4 (31%)
Risk of reinsurer default	2 (5%)	36 (78%)	8 (17%)	1 (3%)	27 (82%)	5 (15%)	1 (8%)	9 (69%)	3 (23%)
Cash flow mismatch	13 (28%)	26 (57%)	7 (15%)	8 (24%)	20 (61%)	5 (15%)	5 (39%)	6 (46%)	2 (15%)
Deterioration of asset values	32 (70%)	14 (30%)	0 (0%)	25 (76%)	8 (24%)	0 (0%)	7 (54%)	6 (46%)	0 (0%)
Government and political action	2 (5%)	37 (80%)	7 (15%)	2 (6%)	26 (79%)	5 (15%)	0 (0%)	11 (85%)	2 (15%)
Off balance sheet (e.g. derivatives)	5 (11%)	29 (63%)	12 (26%)	4 (12%)	21 (64%)	8 (24%)	1 (8%)	8 (62%)	4 (30%)
Unexpected inflation	17 (37%)	23 (50%)	6 (13%)	11 (33%)	18 (55%)	4 (12%)	6 (46%)	5 (39%)	2 (15%)
Interest rate level	36 (78%)	4 (9%)	6 (13%)	27 (82%)	2 (6%)	4 (12%)	9 (70%)	2 (15%)	2 (15%)
Equity returns**	41 (89%)	2 (4%)	3 (7%)	33 (100%)	0 (0%)	0 (0%)	8 (62%)	2 (15%)	3 (23%)
Premium volume	27 (59%)	9 (19%)	10 (22%)	20 (61%)	7 (21%)	6 (18%)	7 (54%)	2 (15%)	4 (31%)
Leverage	0 (0%)	32 (70%)	14 (30%)	0 (0%)	26 (79%)	7 (21%)	0 (0%)	6 (46%)	7 (54%)
Liquidity	0 (0%)	37 (80%)	9 (20%)	0 (0%)	28 (85%)	5 (15%)	0 (0%)	9 (69%)	4 (31%)
Asset mix**	30 (65%)	13 (28%)	3 (7%)	29 (88%)	4 (12%)	0 (0%)	1 (8%)	9 (69%)	3 (23%)
Bonus rate**	28 (60%)	9 (20%)	9 (20%)	27 (82%)	5 (15%)	1 (3%)	1 (8%)	4 (31%)	8 (61%)

Note:
1. *Significant at the 0.05 level; **significant at the 0.01 level.
2. N/A: not applicable

4. Determinants of company performance

The respondents were requested to rate the importance of 15 possible determinants of company performance on a five-point scale, "1" being least important and "5" being most important. The mean importance ratings are reported in Table 6.29. These results reveal that the survey respondents perceived *equity returns, interest rate level, free asset ratio* and *interest rate change*, to be relatively important (i.e. mean importance rating more than "3"). As evidenced in Chapter two, the UK life insurance industry as a whole invested a large significant proportion of its funds in equities and bonds. As a result, it is not surprising that *equity returns* (4.2) and *interest rate level* (3.6) were given the highest ratings due to the fact that life offices were exposed to the fluctuations in the asset values.

Free asset ratio (3.6) was regarded as an important determinant is possibly because it is an indicator of financial strength of a life office. In choosing from among the approximately 200 life offices carrying on long-term business in the UK, the prospective insurance buyer may consider a number of factors. Since the life insurance policy represents a long-term promise on the part of the life office, its financial strength and ability eventually to meet its promise rank as the first consideration. As a result, the free asset ratio of an office plays an important role in business underwriting, which accordingly has an impact on company performance.

Finally, *Interest rate change* (3.3) was also considered a relatively important determinant. This seems to imply that the survey respondents realised that changes in interest rates have much effect on company performance. As to the rest of possible determinants, they were all considered relatively unimportant by the survey respondents.

Table 6.29 also shows the results for with-profit and non-profit offices. Overall, both with-profit and non-profit offices considered the above-mentioned four determinants important. Due to some of the expected frequencies are less than five, a Chi-square test was not conducted to investigate whether there is any differentiation between with-profit and non-profit offices. In order that the Fisher's exact test can be employed the data was collapsed to a 2 by 2 situation ("Importance rating less than or equal to 2 (Code=1)" and "Importance rating greater than or equal to 3 (Code=2)"). As shown in the table, there are two determinants whose p-values associated with the test are less than 0.05, including *equity returns* and *interest rate level*. They will be discussed below.

The mean importance ratings of *equity returns* given by the respondents from with-profit and non-profit offices are 4.8 and 3.0 respectively. An examination of the data revealed that all respondents from with-profit offices gave *equity returns* importance ratings of either "4 or "5", whereas only half of the respondents from non-profit offices did. The p-value associated with the Fisher's exact test is 0.000. This indicates that the null hypothesis of no relation between the type of business and the importance rating of the determinant *equity returns* can be rejected at the 0.01 level. The analysis confirms empirically that from practitioners' point of view the return on equities is more important to with-profit offices than to non-profit offices. As previously mentioned, with-profit contracts are allowed to participate in the profits earned by the fund. The management of with-profit offices has to earn a good return on investments in order to achieve the return guarantees granted to existing policyholders and attract prospective policyholders. Although they are usually associated with great volatility, equities tend to yield a high rate of return in the long run. Therefore, with-profit offices in general invested a higher proportion of their funds in equities than their non-profit counterparts. This is the main reason why the respondents from with-profit offices perceived *equity returns* to be relatively important compared to those from non-profit offices.

The mean importance ratings of *interest rate level* are 3.8 (with-profit) and 3.2 (non-profit). A p-value of 0.048 was obtained, indicating that the null hypothesis of no relation between the type of business and the importance rating of the determinant *interest rate level* can be rejected at the 0.05 level. A further examination of the life offices revealed that approximately three fourths of the with-profit respondents considered *interest rate level* to be relatively important, whereas only one third of the non-profit respondents did. This suggests that the former tended to perceive *interest rate level* more important than the latter. This is again because the management of with-profit offices is under pressure from policyholders and shareholders to earn a good return on investments including fixed interest securities.

In addition, there is another possible reason why the mean importance ratings of the determinants *equity returns* and *interest rate level* were statistically significantly different between with-profit and non-profit offices. As stated previously, equities and bonds are two main invested assets of life offices. In with-profit business the office takes on investment risk to the extent of what the office has guaranteed, although a significant part of the risk is borne by the policyholder via bonus fluctuations. In unit-linked business, for example, investment risk is borne largely by the policyholder. That is, with-profit offices are more exposed to investment risk than their non-life counterparts. This is perhaps the reason why with-profit offices had higher mean importance ratings of these two determinants than non-profit offices.

Table 6.29: The mean importance rating of performance determinants (Life)

Performance determinant	All	With-profit	Non-Profit
Equity returns**	4.2	4.8	3.0
Interest rate level*	3.6	3.8	3.2
Free asset ratio	3.6	3.7	3.2
Interest rate change	3.3	3.4	3.1
Unexpected inflation	2.7	2.7	2.8
Stability of asset structure	2.6	2.6	2.6
Company size	2.5	2.6	2.4
Reinsurance dependence	2.2	2.2	2.4
Stability of underwriting operation	2.1	1.9	2.8
Liquidity	2.1	2.1	2
Life & general annuity reserves as a % of total reserves	1.9	2	1.6
Pension reserves as a % of total reserves	1.9	2.1	1.4
Leverage	1.7	1.9	1.3
Assets held to cover linked liabilities a % of total assets	1.6	1.5	1.7
Permanent health reserves as a % of total reserves	1.2	1.1	1.6

Note: *Significant at the 0.05 level; **significant at the 0.01 level.

5. Modelling related issues

The life offices surveyed were asked whether and how they modelled the term structure of interest rates, inflation, equity returns, currency rates, and credit spreads. The results are presented in Table 6.30. Compared with the non-life results in Table 6.10, there were three main differences between the two. First, the percentages of modelling the first three above-mentioned economic variables in the life sector were much higher than those in the non-life sector. Equity returns (77 per cent), inflation (69 per cent) and term structure of interest rates (47 per cent) are the most frequently modelled economic variables by the life offices, whereas inflation (47 per cent), term structure of interest rates (20 per cent), and equity returns (20 per cent) by non-life organisations. Second, a number of life offices surveyed adopted both deterministic and stochastic approaches. This phenomenon had not been discovered in the non-life survey. Third, most of the life offices which reported modelling the economic variables adopted a deterministic approach, whereas non-life organisations seemed to have no preference for these two approaches.

Table 6.30 also shows the proportions of employing the economic variables within with-profit and non-profit offices. Two observations can be made based on the results. The first is that among the five economic variables *equity returns* is the most frequently modelled variable within with-profit offices, whereas *inflation* within non-profit offices. The reason why *equity returns* was modelled by most of the with-profit offices is mainly because they invested a high proportion of their funds in equities and the return on equity investment was important for the investment performance of offices. *Equity returns* were relatively unimportant to non-profit offices compared with their with-profit counterparts. *Inflation* was the second most frequently modelled variable within with-profit offices, whereas it was the most frequently modelled variable within non-profit offices. Over the past three years, inflation has been low in the UK. The falling inflation has a relatively significant impact on life insurers compared to general insurers.

Many life insurance firms, especially with-profit offices, offer savings products such as pensions which include a guarantee of the minimum annuity rate. On occasion these guarantees put life offices under financial pressure, especially during a period of low inflation and investment returns. As inflation and prospective asset returns have fallen, a number of life assurance companies have to establish large amounts of reserves against the possible future costs of the guarantees. Equitable Life is the most high profile example. This case highlights the importance of modelling inflation and examining its subsequent effects to insurers' solvency.

The second observation is that none of the surveyed non-profit offices modelled the listed variables stochastically, while a number of the with-profit offices did. There were two possible reasons behind this. The first is that with-profit offices were more capable of modelling economic variables than their non-profit counterparts. The second possible reason is that non-profit offices might consider it unnecessary to model the variables stochastically.

Table 6.30: Modelling of economic variables (Life)

Economic variable	All				With-profit				Non-profit			
	No	Yes			No	Yes			No	Yes		
		D	S	D+S		D	S	D+S		D	S	D+S
Term structure of interest rates	27 (53%)	14 (27%)	5 (10%)	5 (10%)	13 (38%)	11 (32%)	5 (15%)	5 (15%)	14 (82%)	3 (18%)	0 (0%)	0 (0%
Inflation	16 (31%)	24 (47%)	5 (10%)	6 (12%)	10 (29%)	13 (38%)	5 (15%)	6 (18%)	6 (35%)	11 (65%)	0 (0%)	0 (0%
Equity returns	12 (23%)	23 (45%)	7 (14%)	9 (18%)	4 (12%)	14 (41%)	7 (21%)	9 (26%)	8 (47%)	9 (53%)	0 (0%)	0 (0%
Currency rates	49 (96%)	1 (2%)	1 (2%)	0 (0%)	33 (97%)	0 (0%)	1 (3%)	0 (0%)	16 (94%)	1 (6%)	0 (0%)	0 (0%
Credit spreads	44 (86%)	3 (6%)	2 (4%)	2 (4%)	28 (82%)	3 (9%)	2 (6%)	1 (3%)	16 (94%)	0 (0%)	0 (0%)	1 (6%

Note:
D: deterministic; S: stochastic; D+S: deterministic and stochastic

Table 6.31 summarises the asset modelling capability of the life offices surveyed. Not surprisingly, the percentages of the five-level modelling capabilities of the life offices were all much higher than those of their non-life counterparts (Table 6.11). Again this confirms the common perception that life offices were relatively capable of carrying out asset modelling. This finding seems to suggest that life offices placed more emphasis on investment operations than general insurance. One explanation is that many life insurance products bundle insurance with investment products.

Table 6.31 also compares the results for with-profit and non-profit offices. It seems that with-profit offices, in particular if they were writing substantial volumes of with-profit business, were more capable of modelling assets than their non-profit counterparts. This is due in part to the fact that in with-profit business only a part of the sum assured may be guaranteed and the balance depends on investment performance.

In order to determine whether the proportions of those falling into each category of asset modelling capability differ by group, the Fisher's exact test was conducted for each category. All the p-values are greater than 0.05 except the one for the category "*can vary income and gains independently*". The associated p-value is 0.001. This indicates that the hypothesis of no relation between the type of business written and this category is rejected at the 0.01 level. This is because with-profit offices usually required relatively flexible asset models in order to allow management to consider the impact of different asset allocation strategies on investment performance during the course of the projection. This is particularly important to with-profit offices as they may have to frequently change their asset allocation according to their financial circumstances and the current market and regulatory environment.

The findings of the life survey are in general similar to those reported by Muir and Sarjant (1997) who found that the asset modelling was more sophisticated for offices who wrote with-profit business than for those who did not. It is important to note that most percentages of the asset modelling capabilities of the with-profit offices in this survey were significantly higher than those in the survey administered by Muir and Sarjant (1997) in 1996. This suggests that the asset modelling capabilities of life offices have been improving over the years. Nevertheless, it is worthwhile to note that Muir and Sarjant (1997) reported 73 per cent of with-profit offices reported using separate model points for different asset classes while only 49 per cent in this life survey did. This is possibly because the modern computer technology makes it easier to conduct complicated analyses of predictions of market values, investment incomes and capital gains for individual assets than ever. It seems likely that the use of model points to represent different asset classes for modelling purposes would be less common in the future.

Table 6.31: The capability of asset modelling (Life)

Capability	All	With-profit	Non-profit	p-value Fisher's exact test
Can project the total investment return	36 (75%)	27 (82%)	9 (60%)	0.152
Assumptions can be varied from year to year	35 (73%)	27 (82%)	8 (53%)	0.077
Can vary income and gains independently**	33 (69%)	28 (85%)	5 (33%)	0.001
Separate model points for different asset classes	20 (42%)	16 (49%)	4 (27%)	0.212
Individual assets can be modelled	10 (21%)	9 (27%)	1 (7%)	0.140

Note: *significant at the 0.05 level; **significant at the 0.01 level.

As one might expect, the liability modelling methods are different for life offices and their non-life counterparts because of the nature of the product mix. Thus, the responses from which the respondents in the two postal survey chose were deliberately made different. The results regarding the methods of liability modelling used by the life offices as a whole, with-profit and non-profit life offices surveyed are shown in Table 6.32.

Table 6.32: The method of liability modelling (Life)

Method	All	With-profit	Non-profit	p-value Fisher's exact test
All in force policies	20 (39%)	11 (31%)	9 (53%)	0.224
A sample of in force policies	3 (6%)	2 (6%)	1 (6%)	1.000
Model points**	21 (40%)	19 (54%)	2 (12%)	0.006
Most in force policies	15 (29%)	10 (29%)	5 (30%)	1.000

Note: *significant at the 0.05 level; **significant at the 0.01 level.

There are two observations can be made based on the results reported in the above table. The first is that on the whole the three most widely used methods of liability modelling in the life sector were model points (used by 40 per cent of all life offices), all in force policies (39 per cent), and most in force policies (29 per cent). It is worthwhile to note that a model point is a representative contract with particular liability characteristics such as benefit amount and contract type. In practice, the liability structure of the model office consisting of a number of model points is simpler than that of the actual office. Under appropriate assumptions regarding the number of policies in force at each model point, a certain number of different model points will be employed such that the liability structure of the model office will be broadly representative of that of the actual office. Nevertheless, due to the development of modern computer technology a large proportion of the life offices (68 per cent) modelled their liabilities using all or most in force policies instead of model points.

The second observation is that in terms of liability modelling methods there were some similarities and differences between with-profit and non-profit offices. The proportions of employing the liability modelling methods "*a sample of in force policies*" and "*most in force policies*" within the two groups were broadly the same. Nevertheless, the proportions of employing "*all in force policies*" and "*model points*" within the two groups seemed different. In order to determine whether there was a differentiation between the two groups, the Fisher's exact test was again conducted for each liability modelling method. All the p-values are greater than 0.05 except the one for "*model points*". Its associated p-value is 0.006. This indicates that the null hypothesis of no relation between the type of business and the use of modelling points can be rejected at the 0.01 level. This suggests that with-profit offices are more likely than their non-profit counterparts to use model points to do liability modelling. An examination of non-profit data revealed that only 12 per cent of non-profit offices surveyed projected their liabilities using model points, whereas 53 per cent using individual policy projections. This is probably because the liabilities of non-profit offices were less complicated than their with-profit counterparts. Accordingly individual policy projections were relatively feasible in this case.

More than half of the with-profit offices (54 per cent) reported using model points. Thirty one per cent indicated that all in force policies were used to model their liabilities, while 29 per cent most in force policies. Only six per cent used a sample of in force policies. These findings are broadly in line with those reported by the Dynamic Solvency Testing Working Party (1994) in a sense. In the Working Party's survey of 29 with-profit offices, the proportions of the respondents using model points, most of in force policies, and a sample of in force policies were 69 per cent, 34 per cent, and 7 per cent respectively. It is important to note that none of the with-profit offices surveyed in the Working Party's survey was capable of modelling liabilities using all in force policies. This suggests that over the years there has been an increasing tendency towards the use of all in force policies by with-profit life offices.

The respondents employing model points were asked the number of them used. There was a considerable diversity of the number of model points used. The number ranged from 100 to 1,000,000. In fact, the number of model points mainly depends on purposes. One Appointed Actuary of a with-profit office stated that 150,000 model points were used to calculate embedded value, while only 2,500 for conducting DST.

As regards the method of liability modelling, a number of comparisons can be drawn between the life and non-life surveys. First, none of the general insurers surveyed used a sample of in force policies in aggregate or individually. Like general insurers, very few life offices (six per cent) modelled their liabilities in this manner. Again this is possibly due to the advanced computer technology. In general companies were able to use all or most of in force policies to model liabilities if they wanted to. Second, using model points to model liabilities was only commonly seen in the life industry. Only a very small number of non-life companies reported using model points due to the nature of non-life business. This is perhaps because it was inappropriate for non-life companies to use model points.

6. Forecast period

Table 6.33 presents the results regarding the length of the forecast periods in DST and in business plan. Most of the life offices (46 per cent) reported using a five-year forecast period in DST. This finding seems to conflict with the finding reported by Muir and Sarjant (1997) that the most common projection period was 20 years. Nevertheless, since the projection would become relatively unreliable as the projection period is lengthened, many life offices only paid attention to the results of the first few years. Muir and Sarjant (1997) indicated that generally only the first five-year results were presented to the Board. In general, a five-year projection is adequate for a typical life office, as suggested by the Canadian DCAT Standard of Practice (Canadian Institute of Actuaries, 1998). However, it is generally agreed that the Appointed Actuary should consider whether choosing a longer period would be instrumental in monitoring the solvency position. In this survey, a large proportion (44 per cent) reported using a projection period of more than six years.

Table 6.33: The length of the forecast periods in DST and BP (Life)

Length of forecast period	All		With-profit		Non-profit	
	DST	BP	DST	BP	DST	BP
1 year	0 (0%)	2 (4%)	0 (0%)	2 (6%)	0 (0%)	0 (0%)
2 years	1 (2%)	2 (4%)	1 (3%)	1 (3%)	0 (0%)	1 (6%)
3 years	3 (6%)	16 (31%)	1 (3%)	11 (31%)	2 (12%)	5 (29%)
4 years	1 (2%)	2 (4%)	0 (0%)	0 (0%)	1 (6%)	2 (12%)
5 years	24 (46%)	24 (46%)	15 (43%)	17 (49%)	9 (53%)	7 (41%)
6~10 years	15 (29%)	6 (11%)	11 (31%)	4 (11%)	4 (23%)	2 (12%)
11~15 years	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
16~20 years	1 (2%)	0 (0%)	1 (3%)	0 (0%)	0 (0%)	0 (0%)
> 20 years	7 (13%)	0 (0%)	6 (17%)	0 (0%)	1 (6%)	0 (0%)

Note:
DST: Dynamic Solvency Testing; BP: business plan

As evidenced in the previous section, in non-life business the projection period in DFA was significantly correlated with that in business plan. Nevertheless, it appears that this is not the case for the surveyed life offices as a whole. In order to test the null hypothesis of no relation between the projection period in DST and that in business plan, Kendall's tau-b and Spearman's rho correlation coefficients were calculated. As presented in Table 6.34, both of them are insignificant at the 0.05 level. In fact, the DST projection period was longer than the business-planning horizon on average. As shown below, most of the life offices employing a long DST projection period were with-profit offices.

As presented in Table 6.33, with-profit and non-profit offices had significantly different distributions of the length of projections periods. Three per cent of the with-profit offices reported using a period of 16-20 years for DST, and 17 per cent more than 20 years. None of them indicated that a period of more than 10 years was used for business plan. Non-profit offices generally employed a shorter projection period. Only six per cent of them reported using a projection period of more than 20 years. Due to the nature of non-profit business, it seems unnecessary for non-profit offices to make very long-term forecasts. These findings suggest that most of the life offices employing a long DST projection period were with-profit offices. Moreover, Kendall's tau-b and Spearman's rho correlation coefficients were calculated for with-profit and non-profit offices and reported in Table 6.34. It is noted that these correlation coefficients for with-profit offices are relatively small compared to those for non-profit offices. The associated p-values for the former are both greater than 0.05, while those for the latter are less than 0.05. This indicates that the null hypothesis of no relation between the forecast period of DST and that of business plan cannot be rejected at the 0.05 level for the former, but can be rejected for the latter. These findings together suggest that in non-profit business the forecast periods of DST and of business plan were correlated, but they were not in with-profit business. In fact, the DST projection period used by most of the with-profit offices (92 per cent) was longer than the business-planning projection period. Moreover, with-profit offices with better modelling capability in terms of the number of techniques employed were more likely to project DFA results for a longer period. However, they still tended to use the business-planning horizon of less than five years. Consequently, most of them used unequal length of DST forecast period and business-planning horizon.

Table 6.34: The correlation coefficient of the forecast periods (Life)

Correlation coefficient	All	With-profit	Non-profit
Kendall's tau-b	0.166 [0.142]	0.059 [0.702]	0.388 [0.025]*
Spearman's rho	0.195 [0.167]	0.077 [0.659]	0.535 [0.041]*

Note:
1. *Significant at the 0.05 level; **significant at the 0.01 level.
2. p values are in brackets.

7. Considerations of DST results by senior management

The results of the extent to which the senior management incorporated the DST result considerations in their decision making processes are summarised in Table 6.35.

Table 6.35: The incorporation of DST results in decision making process (Life)

Extent	All	With-profit	Non-profit
Always	10 (21%)	5 (16%)	5 (29%)
Usually	16 (33%)	12 (39%)	4 (24%)
Often	7 (15%)	6 (19%)	1 (6%)
Occasionally	13 (27%)	8 (26%)	5 (29%)
Never	2 (4%)	0 (0%)	2 (12%)

As presented in the above table, a large proportion of respondents (54 per cent) indicated that DST result considerations were *always* or *usually* involved in the decisions made by the senior management of their offices, whereas a significant proportion (42 per cent) indicated *often* or *occasionally*. Only two respondents (four per cent) indicated that such considerations were never made, although they produced DST results.

A further examination of the data revealed that the respondents who reported producing DST result within their organisations but the results were never incorporated in the decision making processes of their senior management were all from non-profit offices. Basically, GN2 is geared to with-profit offices. This is the possible reason why the senior management of a number of non-profit offices which produced DST results did not incorporate the results in their decision making processes. Nevertheless, 29 per cent of the respondents from non-profit offices indicated that DST result considerations were *always* involved in the decisions made by the senior management of their offices. These findings together suggest that the senior management of the non-profit offices had a difference of opinion about the importance of DST results. In contrast, the senior management of the surveyed with-profit offices, at least occasionally, incorporated DST results in their decision making processes.

On the whole, it seems that there is no major difference between life offices and their non-life counterparts. This is possibly because the senior management of the insurance firms employing the financial techniques generally believed that the incorporation of DST/DFA results in the decision making process was useful in the operation of an insurance company.

8. Difficulties experienced in communicating the DST results to the Board

The results regarding the difficulties experienced in communicating the DST results to the Board are summarised in decreasing order of significance in Table 6.36. The two most commonly seen difficulties are: *difficulties in communicating complex issues to non-specialists* (51 per cent), and *how to present extremely adverse scenarios without causing undue concern* (39 per cent). As evidenced in the previous section, the former was also the most common difficulty faced by the non-life respondents (54 per cent). It seems that this was a very common difficulty experienced by actuaries while communicating the DST/DFA results to the Board. The latter is concerned with the presentation of extremely adverse scenarios to the Board. Since life offices, in particular with-profit offices, generally involved heavily in complicated underwriting and investment operations, they were very likely to encounter the above-mentioned difficulties. The reasons behind this will be presented and discussed below.

A number of the respondents who ticked the box for "*other*" provided the following answers to this question. For example, "*we do not provide much detail*", "*need to identify what risks can be managed, and how, and what are outside direct control, and what mitigation strategies can be used*" and "*asset-liability issues are a minor risk for our business*". In addition, two respondents stated that no particular difficulties have been experienced.

Having examined the difficulties experienced by the respondents from the surveyed life offices as a whole, the Fisher's exact test was conducted for each type of the difficulties listed to determine whether there is any differentiation between with-profit and non-profit offices. The results are also presented in Table 6.36. The associated p-values for the difficulties "*how to present extremely adverse scenarios without causing undue concern*" and "*difficulties in communicating complex issues to non-specialist*" are 0.006 and 0.040 respectively. This indicates that the null hypotheses of no relation between the type of business and each of these difficulties can be rejected at the 0.01 and 0.05 levels respectively. These findings suggest that with-profit offices were more prone to experience these difficulties than their non-profit counterparts. This is again because with-profit business is relatively complicated compared to non-profit business. In general the issues considered in DST by with-profit offices were more complex than those by non-profit offices. For instance, the recent problems with guaranteed annuity rates have become an importance issue for with-profit offices. Many of them have started to review the level of guarantees being offered and whether these are being properly charged for. With-profit offices in general have to set investment and bonus policies, including the modelling of the interaction of bonus rates, investment policy and statutory solvency. When complicated issues like this arise, the difficulty in communicating these issues to non-specialists frequently occurred. In addition, due to the complexity of investment operations and the volatility of the economic situation, the scenarios built in DST for with-profit business were relatively complicated and some of extremely adverse scenarios were unavoidable. It is likely that these extremely adverse scenarios may cause undue concern when the analyst presents the DST results to the Board.

Table 6.36: Difficulties in communicating DST results to the Board (Life)

Difficulty	All	With-profit	Non-profit	p-value Fisher's exact test
Difficulties in communicating complex issues to non-specialists *	26 (51%)	21 (62%)	5 (29%)	0.040
How to present extremely adverse scenarios without causing undue concern **	20 (39%)	18 (53%)	2 (12%)	0.006
Concern regarding the degree of conservatism in selecting adverse scenarios	10 (20%)	9 (27%)	1 (6%)	0.135
Lack of interest	5 (10%)	3 (9%)	2 (12%)	1.000
Too much focus on assumptions rather than results	5 (10%)	4 (12%)	1 (6%)	0.654

Note: *significant at the 0.05 level; **significant at the 0.01 level.

9. Main reasons for not using the DST related techniques

There were only one with-profit and four non-profit offices reported not using these techniques. This with-profit office indicated *lack of need*, *too expensive*, and *lack of appropriate asset or liability models* are the main reasons. This most striking result is that this office did not consider it necessary to use DST techniques to derive the background information underlying the FCR which this company produced annually. After further examination of this office, it was a small company which was going to cease business in the near future with all of its policies transferred to another insurer as of the time the survey was administered.

The above reasons were also cited by the four non-profit offices. Two of them did not feel the need for DST. This is possibly because GN2 is geared to with-profit offices. It is also noted that none of these with-profit and non-profit offices indicated that *lack of relevant knowledge* or *experience* is the main reason. This is probably because every life office has an Appointed Actuary who is supposed to have relevant knowledge and experience.

10. Use of financial condition report

As in the non-life survey, the life offices surveyed were asked whether they produced FCR or its equivalent. The proportion of the life offices (95 per cent) reported producing FCR is much higher than that of their non-life counterparts (27 per cent). This is mainly because GN2 is classified as recommended practice in long-term business and there is currently no such a Guidance Note in general business. Of these life offices producing FCR, 98 per cent produced it annually. Only one with-profit office reported producing it triennially. An examination of the data for this company revealed that there was no DST related techniques employed within the organisation and that in the future this firm expects to complete FCR on an annual basis in line with GN2. These findings together suggest that producing FCR annually had become the norm in the life sector. One explanation for this is that GN2 suggests that in the normal course of events the FCR should be produced annually.

The relationship between the type of business written and the production of FCR is analysed in the Table 6.37.

Table 6.37: The type of business and the production of FCR (Life)
Fisher's exact test (p-value = 0.049)

	Production of FCR	
	No (Code = 1)	Yes (Code = 2)
With-profit office (Code = 1)	0	36
Non-profit office (Code = 2)	3	19

The results presented in the above table show that all the with-profit offices produced FCR. Eighty six per cent of the responding offices only transacting non-profit business did it, too. The Fisher's exact test was conducted, resulting in a p-value of 0.049. This indicates that the null hypothesis of no relation between the type of business written and the production of FCR can be rejected at the 0.05 level. The conclusion is that the proportion of production of FCR within with-profit and non-profit offices differs. This finding therefore provides support for the hypothesis by showing that the use of FCR was more commonly seen in with-profit business than in non-profit business.

The life offices surveyed were asked whether the FCR is available to their auditors and the FSA. Seventy nine per cent stated that the FCR is available to their auditors, and 77 per cent to the FSA. Two Appointed Actuaries of the life offices whose FCR is available to the FSA specifically stated that they only make it available to the FSA if requested. One reason these offices felt reluctant to submit the FCR to the regulatory authority is that premium revenues may be adversely affected if the information on the FSA's subsequent measures which might be premature is released and interpreted improperly.

The life offices were also asked whether the FSA should have automatic access to the FCR. Eighty three per cent agreed that the FSA should have the automatic access. Two Appointed Actuaries who agreed on this matter stated that the FSA only has the automatic access to the FCR on condition that the FCR is not made public. The reason is that the public may not be able to correctly interpret the information on the financial condition of the company and some undue concern may arise.

The life offices were asked about the extent to which GN2 is acceptable and were requested to rate the acceptability of GN2 on a five-point scale, "1" being least acceptable and "5" being most acceptable. The results are shown in Table 6.38.

Table 6.38: The type of business and the extent to which life offices find GN2 acceptable (Life)

	The extent of acceptability				
	1	2	3	4	5
	Least acceptable				most acceptable
With-profit office	0	1	6	27	2
Non-profit office	1	0	7	6	3

The main finding emerging from the results reported in the above table is that it is generally agreed that GN2 is acceptable. Although GN2 generally is found acceptable, a number of additional comments volunteered by the respondents to the survey suggest that there is still room for improvement. For example, one Appointed Actuary who gave a rating of "4" proposed that:

"*GN2 should be made mandatory.*"

The view expressed in the quotation presented above cannot be regarded as representative, however. On the whole, GN2 is relevant to with-profit business. A significant part of GN2 is not applicable for non-profit business. Since non-profit offices usually do not need sophisticated modelling of assets and liabilities, they would find GN2 less useful.

Another Appointed Actuary who also gave a rating of "4" commented:

"*GN2 is acceptable as not mandatory. If GN2 had to be followed to the letter then there would be a need to improve it.*"

This quotation indicates the importance of improving GN2 if it is made mandatory, but it does not suggest the ways of doing it. It would be useful to find out practitioners' views on how to improve GN2. This will be investigated further using the interview method.

6.4 Summary and Conclusions

The purpose of this chapter was to present the evidence from two postal surveys regarding the investigation of the current DFA/DST/FCR practices in the UK insurance industry.

The usable response rates of the non-life and life surveys were 28 per cent and 71 per cent respectively. One explanation for the huge difference between the two is as follows. Since 1996 most life offices have complied with GN2 by employing financial techniques to obtain corporate information underlying the FCR. As a result, life offices found the questionnaire relevant to their business and would be relatively willing to complete and return the questionnaire. It is believed that the high response rate achieved for the life survey is partly because of the actions taken to maximise response rate. Additionally, the high response rate suggests a high level of practitioner interest in the subject of DST and FCR. In contrast, there is currently no Guidance Note on FCR for general insurers. Besides, the terminology of DFA is still fairly new to most of practitioners in the non-life sector. It seems that the topic, the current practice of DFA/FCR, is not of particular relevance to non-life practitioners. Therefore, it is not surprising that the response rate of the non-life survey was relatively low.

This study contributes to the academic literature in three main regards. Firstly, the non-life survey is the first comprehensive survey of its kind to investigate the current DFA and FCR practices in the UK general insurance market. Secondly, the life survey is an up-to-date survey of the DST and FCR practices in the UK life sector since the survey by Muir and Sarjant (1997) which was administered in 1996 shortly after GN2 was introduced into the life insurance industry. The results of the study indicate that life offices' ability to employ financial techniques have been improving over these years. Thirdly, these two concurrent surveys make the comparison of the practices between the two insurance sectors possible. A number of differences between non-life and life businesses are discovered.

This study provides a unique perspective into the use of the DFA/DST techniques and FCR in the insurance industry. Among the more important insights generated by this study are the following:

6.4.1 The Use of Dynamic Financial Analysis / Dynamic Solvency Testing Related Techniques

For convenience and simplicity, the major empirical findings concerning the similarities and differences in the DFA/DST practices between the non-life and life insurance sectors are summarised in Table 6.39.

Table 6.39: The similarities and differences in the DFA/DST practices between the non-life and life sectors

	Non-life insurance	Life insurance
Proportion of using DFA/DST techniques	41%	90%
The most popular DFA/DST technique	Scenario testing (35%)	Scenario testing (79%)
The most commonly seen DFA/DST application	Evaluation of reinsurance programme (64%)	Solvency testing (98%)
Number of scenarios run regularly	Less than ten scenarios (84%)	Less than ten scenarios (89%)
Most common frequency of using scenario testing	Monthly (33%) and half yearly (33%)	Annually (61%)
Most common risk category	Levels of new business (83%)	Future investment conditions (100%)
Performance determinant with highest rating	Stability of underwriting operation (3.5)	Equity returns (4.2)
Most frequently modelled economic variable	Inflation (47%)	Equity returns (77%)
Capability of asset modelling	Individual assets can be modelled (0%)	Individual assets can be modelled (21%)
Most common method of liability modelling	All in force policies in aggregate (50%)	Model points (40%)
Most common forecast periods in DFA/DST and BP	DFA: three years (34%) BP: three years (34%)	DST: five years (46%) BP: five years (46%)
Incorporation of DFA/DST results in decision making process	Always (14%); usually (36%); often (21%); occasionally (29%); never (0%)	Always (21%); usually (33%); often (15%); occasionally (27%); never (4%)
Most common difficulty in communicating DFA/DST results to the Board	Difficulties in communicating complex issues to non-specialists (54%)	Difficulties in communicating complex issues to non-specialists (51%)
Main reason for not using DFA/DST techniques	Lack of need (76%)	Lack of need (60%)

One of the most important contributions of the non-life and life surveys has been to show that the proportion of the sample life offices using financial techniques is higher than that of general insurers. Moreover, the offices were more capable of using techniques than non-life counterparts. Furthermore, the results confirm the common perception that investment operation was considered more important than underwriting operation in life insurance compared to general insurance. This is mainly because a large proportion of the products provided by life insurance firms are investment-related.

Compared with their life counterparts, the non-life insurers conducted scenario tests on a relatively frequent basis. This is partly because non-life business is more volatile than life business. In addition, most of the sample life insurers used model points to model their liabilities, whereas most of the general insurers used all in force policies in aggregate. This is due in part to the nature of their business.

It is generally agreed that the forecast period would have to be long enough to capture the adverse effect of the risk factors faced by the company. The survey results show that life offices had longer forecast periods in DST / business plan than their non-life counterparts in DFA / business plan. This is because the business of the former is, in general, relatively long-term, compared with that of the latter.

This chapter has also described and discussed the findings for different types of insurance. Many observations have already been made based on the results and discussed. Nonetheless, it seems that based on the non-life data used in this study there is only one statistically significant difference between the types of general insurance offered, perhaps due in part to the possible "small sample" problem. The results of the study indicate that motor insurers are more likely to test the assumptions concerning *liquidity*.

Unlike general insurance, there are many differences between with-profit and non-profit businesses were identified in life insurance. The major differences are: (1) with-profit offices are more capable of using DST techniques and tend to use more techniques than their non-profit counterparts, (2) the proportion of using scenario testing and stochastic simulation is relatively high in with-profit business compared to non-profit business, (3) with-profit offices are more likely to apply DST techniques to capital and asset allocation than their non-profit counterparts, (4) *allocation of profit*, *equity returns*, *asset mix*, and *bonus rate* are relatively commonly seen in the scenarios tested by with-profit offices, (5) the asset modelling capability of varying income and gains independently is different between the two businesses, (6) with-profit offices are more likely to use model points to carry out liability modelling than non-profit offices, (7) in non-profit business the forecast periods of DST and of business plan are correlated, but they are not in with-profit business, and (8) when communicating DST results to the Board, with-profit offices relatively frequently have difficulties in explaining complex issues to non-specialists and presenting extremely adverse scenarios without causing undue concern.

6.4.2 The Use of Financial Condition Reports

Nearly all of the life offices surveyed produced FCR on an annual basis, whereas only about one fourth of non-life respondents did. This is probably because GN2 is classified as recommended practice for life offices and there is no such a Guidance Note for non-life insurance companies. The non-life respondents indicated that *lack of need* was the main reason for not producing FCR. In general FCR was available to the company's auditors and the FSA. Most of the life offices surveyed agreed that the FSA should have automatic access to FCR. However, it is generally agreed that the FCR should not be made public in order not to cause undue concerns.

It is debatable whether a Guidance Note on FCR should be introduced for general insurers. Approximately half of the non-life respondents indicated that such a Guidance

Note is necessary. The main reason why more than half of the non-life respondents objected to the introduction of a Guidance Note for non-life companies is probably because actuaries preferred to be left with complete discretion to make profession judgement on what should be carried out in FCR.

Most of the life offices surveyed agreed that GN2 is acceptable. However, since non-profit offices usually do not need sophisticated modelling of assets and liabilities, they would find GN2 less useful.

The non-life and life surveys provided a wealth of informative data. However, following analysis of the survey data, a number of issues on the DFA/DST/FCR practices remained to be addressed. These include:

1. The ability to use these techniques and allow interactions between assets, liabilities, and other factors.
2. The methods of identifying important risk factors.
3. Has any material measure in underwriting or investment operations been taken due to the results of DFA/DST?
4. The factors which limit the ability to use these techniques.
5. The improvement in the features of these techniques in the near future.
6. What does the company include in FCR?
7. Opinions about the introduction of a Guidance Note on FCR for general insurers.
8. Opinions about the improvement in GN2.
9. Opinions about the use of FCR.
10. The improvement in FCR in the near future.

In order to investigate these issues, more detailed investigation and understanding was deemed necessary. It was decided that the best means by which to achieve a deeper understanding was by means of a follow-up interview schedule. An outline and analysis of the interview data will be presented in the following chapter.

Chapter Seven

The Current Practices of Dynamic Financial Analysis: Interview Evidence

7.1 Introduction

As evidenced in the foregoing chapter, the industry surveys provide a wealth of data on the Dynamic Financial Analysis (DFA)/ Dynamic Solvency Testing (DST)/ Financial Condition Reporting (FCR) practices. In order to have a complete picture more relevant issues which have been identified and presented in the previous chapter, need addressing.

This chapter presents the findings obtained from the five interviews that were conducted in July 2002. These findings enrich the results of these postal surveys by providing a more detailed account of the current practices within these five organisations interviewed. It should be noted that the practices discovered at the interviews do not necessarily represent those within other organisations in the survey population. It is worth emphasising that the interview evidence presented here is only indicative, not absolutely conclusive.

The chapter is set out as follows. Section 7.2 presents the profiles of the participants in the interview programme. Section 7.3 lists the topics for discussion at the interview. Section 7.4 reproduces a brief synopsis of each interview. In Section 7.5, the interview results are presented, and compared to the survey findings to explore the validity of the surveys. The final section summarises and concludes this chapter.

7.2 Interview Participants

The five actuaries selected for interviews had responded to either the life or non-life surveys distributed in May 2002 and had indicated that they would be willing to be interviewed as part of this research. As interview participants were assured of complete confidentiality, no single company will be identified. Nevertheless, whilst not compromising the confidentiality agreement reached, the organisations are classified in Table 7.1. As stated in Chapter five, the organisations were selected on the basis of organisational type and the use of DFA/DST/FCR. By selecting on this basis, it was intended to identify insurance companies which would represent a diverse range of views. This table also shows the title of the interviewee and the insurance contracts which the company sold. These organisations were different in terms of the insurance contracts sold. Due to the nature of the business, it is understandable that these organisations might not necessarily have the same practices of DFA/DST/FCR.

Table 7.1: A profile of the interview participants

	Insurer A	Insurer B	Insurer C	Insurer D	Insurer E
Type	Life	Life	Life	Non-life	Non-life
DFA/DST	*	*	*	*	*
FCR	*	*	*	*	
Title of interviewee	Statutory Reporting & Pricing Manager	Appointed Actuary	Actuarial Manager	Pricing Actuary	Chief Actuary
Insurance contract sold	NL AWP PL	Closed to new business	NL PL	AH; MAT L; M P; MP	Closed to new business

Note:

NL: Non-linked contract (other than with-profit policy)
AWP: Accumulating with-profit policy
PL: Property linked contract
IL: Index linked contract
AH: Accident & health insurance
MAT: Marine, aviation and transport insurance
L: Liability insurance
M: Motor insurance
P: Property insurance
MP: Miscellaneous & pecuniary loss insurance

In order to have a more in-depth understanding of the profile of these interview participants, the survey findings regarding the current practice of DFA/DST/FCR within the organisation are summarised in Table 7.2. This table only compares the responses of the questions which were listed in both the non-life and life surveys. It shows that the use of DFA/DST techniques varies within the organisations. In addition, according to the survey results presented in the previous chapter, the modelling capability of the two non-life interview participants was better than that of the other non-life insurance companies in the survey population. Therefore, it seems that these two non-life interview participants were not representative of the other non-life insurance companies in terms of their modelling capability.

Table 7.2: The survey findings regarding the DFA/DST/FCR practices of the interview participants

	Insurer A	Insurer B	Insurer C	Insurer D	Insurer E
DFA/DST technique[1]	SenT SceT SS	SenT SceT	SenT	SceT SS	SenT SceT SS
Number of application[2]	6	1	2	2	3
Number of scenario	1-10	1-10	N/A	1-10	1-10
Frequency of scenario testing	Annually	Annually	N/A	Quarterly	Half yearly
Number of risk categories in scenarios[3]	10	7	N/A	4	9
Economic variable modelling[4]	2	0	2	0	5
Asset modelling[5]	I	I	I	I, II, III	I, II, IV
Liability modelling[6]	I	II	I	V	I
Forecast period	5 years	5 years	5 years	3 years	> 20 years
FCR available to a third party?	Yes	Yes	Yes	Yes	N/A

Note:

1. SenT: sensitivity testing; SceT: scenario testing; SS: stochastic simulation.
2. Ten applications of the DFA/DST related techniques were listed in the questionnaire. The number indicated in this table is the number out of the ten applications listed.
3. Twenty-seven and twenty risk categories were listed in the life and non-life questionnaires respectively. The number indicated in this table is the number out of those listed categories.
4. Six economic variables were listed in the questionnaire. The number indicated in this table is the number out of the six variables listed.
5. I: can project the total investment return; II: assumptions can be varied from year to year; III: can vary income and gains independently; IV: separate model points for different asset classes; V: individual assets can be modelled.

6: I: all in force policies; II: most in force policies; III: a sample of in force policies; IV: model points; V: a sample of in force policies individually;

7.3 Topics for Discussion at the Interview

As stated in both Chapter five and the previous section, the five organisations interviewed can be classified into three categories. This classification is based on the company's organisational type and status of using DFA/DST/FCR. Accordingly three slightly different copies of topics for discussion were made to suit different situations. These copies are included in Appendix C.

The topics were grouped under three main headings which were entitled: "The Risk Profile of your Company", " The Use of Dynamic Financial Analysis (or Dynamic Solvency Testing) Techniques in you Company", and " Financial Condition Reporting in your Company".

1. The risk profile

At the commencement of the interview, the risk profile of the company was discussed with a view to understanding what kind of risks the company was exposed to and to what extent. The risk profile of the company is supposed to be highly related to the techniques which the company uses to quantify the risks it faces and to model its assets and liabilities.

In addition, the interviewees were asked how their companies identify the material risks affecting company performance, i.e. the determinants of company performance. This sought to confirm whether or not actuaries identify these risks mainly based on their professional judgement.

2. The use of Dynamic Financial Analysis/ Dynamic Solvency Testing

This part of discussion was intended to investigate some important issues regarding DFA/DST. For example, the company's capability of using DFA/DST related techniques, the factors which limit the ability of the company to use these techniques, and the improvements to the features of the techniques in the near future, etc.

3. Financial condition reporting

Those interviewees whose organisations produced FCR were asked what their FCR included and what additional features will be added in the near future. Those interviewees whose organisations did not produce FCR were invited to expand on the responses given in their questionnaire document as to why they chose not to do so, and to discuss the possibility of producing FCR in the near future. Moreover, in order to investigate whether it is necessary to introduce a Guidance Note on FCR for non-life insurance companies, the interviewees whose organisations are in the non-life sector were requested to express their opinions on this. The interviewees whose organisations are in the life sector were invited to make suggestions for improvements to GN2. All interviewees were elicited their opinions on whether they regarded FCR as a worthwhile exercise.

7.4 The Synopsis of Interview Participants

Five organisations were interviewed in this research. The name of each organisation has been withheld due to confidentiality assurance given to participants. The full transcripts of interviews can be found in Appendix C in chronological order. For simplicity and convenience, a brief synopsis of each interview is reproduced below.

1. Insurance Company A

Insurance Company A is a life insurance firm which uses DST and produces FCR. The company sells traditional non-profit contracts, accumulating with-profit policies, and property linked contracts. The main risks the company faces are investment and mortality risks. Investment risk is the key one because most of the company's contracts are investment related. The ways of identifying the main risks such as investment risk is obvious to the company, but it has difficulty in quantifying operational risk and business risk. Thus, the DST that the company uses is only focused on the changes in the investment market. Both sensitivity testing and scenario testing are used, whereas stochastic simulation is only applied to certain business lines. The projections are mainly deterministic and the forecast period is five years. The decision about which risk factors should be tested is mainly based on professional judgement. The results of DST investigations are deemed important and have led the company to take material measures in both underwriting and investment operations. Technology and data are regarded as two biggest factors which limit the ability to use DST techniques. The company plans to improve the application of stochastic simulation in the near future. The company fully complies with GN2 and suggests that GN2 be made mandatory. FCR is regarded as a worthwhile exercise.

2. Insurance Company B

Insurance Company B is a life insurer which uses DST and produces FCR. The company does not face any risk with respect to new business because it is closed to new business. The main risks are interest rate risk and mortality risk. The company largely relies on its Appointed Actuary's professional judgement to identify risks. Sensitivity testing is the main technique used by the firm. The use of scenario testing is very limited. Stochastic simulation has never been used, but will be developed in the near future. No interactions are allowed between assets and liabilities. The DST results have never affected company decisions about underwriting and investment operations. The difficulty in writing models and the cost for doing so are the main practical difficulties. The company complies with GN2 to some extent and its Appointed Actuary argues that GN2 should be scraped. FCR is regarded as a worthwhile exercise and stochastic work will be included in FCR in the near future.

3. Insurance Company C

Insurance Company C is a life office which uses DST and produces FCR. The office sells unit-linked contracts and major annuity products. The main risks are expense, lapse and mortality risk. The company investigates its risk profile by doing relevant analyses regarding these main risks. Only very limited sensitivity testing is carried out due to lack of resources. The decision about which risk factors should be tested is largely based on professional judgement. The firm does not have a unified model to allow for interactions between assets and liabilities. The DST results have never directly affected company decision. People and information technology are the two most significant factors limiting the capability for using DST techniques. The company intends to do more work on stochastic modelling in the near future.

4. Insurance Company D

Insurance Company D is a non-life insurer which uses DFA and produces FCR. The company writes all major lines of business, including accident & health, marine, aviation, & transport, liability, motor, property, and miscellaneous & pecuniary loss. The main risks include premium risk, reserving risk, and credit risk, and so forth. A proprietary system is used to manage the aggregate risk exposure and is able to indicate the risk profile of each risk. The company has a mini-DFA model for pricing only and hopes to have an overall model combining assets and liabilities to evaluate different company strategies. In the mini-DFA model two variables, claim severity and frequency, are varied. Wilkie investment model is not used because the company's business is generally short-term. On many occasions the results of DFA investigations have led the company to take decisions about whether to write contracts on certain terms. It is company culture that limits the use of DFA techniques. FCR is regarded as a worthwhile exercise and a Guidance Note on FCR for general insurers is considered necessary.

5. Insurance Company E

Insurance Company E is a non-life insurance firm which uses DFA, but does not produce FCR. The company is a run-off company covering all types of general business. The main risks the company faces are centred around its liabilities. The biggest uncertainty is asbestos liability. The company tends to rely on in-house knowledge and expertise more than anything else in terms of understanding its risks. All DFA related techniques are used. In this company, establishing which risk factors should be tested is quite judgmental. Pricing inflation is used as the key driving factor and Wilkie investment model is used as part of the main model because the company is interested in the long-term results of projections. DFA is used to evaluate investment strategies. The DFA results have never led any changes in underwriting operations. The parameterisation of DFA model is regarded as the biggest factor which limits the use of DFA. Most of the parameters are selected subjectively. These parameters will be updated continuously to reflect the latest market conditions. The company does not produce FCR due to the nature of the company, but it will do if it is required by the regulator. A Guidance Note is deemed necessary, if FCR is made mandatory.

7.5 Interview Outcomes

The five interview transcripts were analysed using colour-coding techniques. The interview outcomes are presented grouped by three key themes which are entitled "the risk profile", "the use of Dynamic Financial Analysis/ Dynamic Solvency Testing", and "Financial Condition Reporting". The order of the topic discussion below is the same as that of the topics listed in the interview instruments provided in Appendix C.

1. The risk profile

The risk profiles of the interviewed organisations are quite different due to the varied business which they write. Investment risk is the most common main risk in most of the organisations, particularly with-profit life offices. Mortality risk presents a fairly significant degree of risk for the life offices which transact pension and annuity business. For unit-linked offices, expense and lapse risks are two common risks. One non-life insurer transacting long-tail liability business indicated that asbestos claims continue to be the greatest single threat to the stability of the company. If the reserves of the company are inadequate, the reserving risk could lead the company to insolvency. For instance, the insolvency of Sovereign Marine & General Insurance Company resulted from the fact that its underwriting results worsened during the period 1988-1990 due to a steady rise in product-related hazard claims such as asbestos, pollution, and workers' compensation claims (KPMG, 1999).

When asked how to identify material risks affecting company performance or how to establish which risk factors should be tested, most interview participants confirmed that it was mainly based on professional judgement without conducting any analysis for the identification of the risk factors. Nevertheless, professional judgement is not always completely reliable. Only one interviewee stated that some analyses such as expense, mortality, and lapse analysis were carried out in order to investigate the risk profile of the company. It is deemed useful to conduct a statistical or econometric analysis in which actuarial judgement is still indispensable, to help actuaries correctly identify the factors which affect company performance and that should be considered being included in DFA/DST modelling. Chapter eight of the thesis will show how the analysis can be done using panel data sets.

2. The use of Dynamic Financial Analysis/ Dynamic Solvency Testing

The importance of conducting DFA/DST was confirmed by all organisations. One of them only carried out sensitivity testing, while the remainder employed two or three techniques within their companies. This suggests that between organisations the use of DFA/DST related techniques varied considerably.

It seems that the insurers reporting conducting stochastic modelling only used it in a very limited way. This was confirmed by one interviewee who indicated in the questionnaire that "*we only apply stochastic simulation to certain business lines*". At the interview, he further indicated that "*this is probably a fairly common position at the moment. I cannot imagine that any company is able to apply to stochastic techniques to its complete in-force book of business*". The use of stochastic modelling was not commonly seen in the insurance industry is possibly because this approach involves costly investments in intellectual development and systems infrastructure. It requires substantially more computing power than scenario testing. Also, to carry out simulations can be a very time-consuming job. Moreover, since the simulation method is prone to model risk, skilled analysts who have a complete understanding of the underlying risk factors are required for this job.

When asked specifically about the extent of allowing for interactions between assets and liabilities, those who mainly transact unit-linked contracts confirmed that "*we can allow to the extent we have to, but that is very limited*" or that "*we do not have a unified model and it (the interaction) is not very important*". Moreover, one non-life company that conducted stochastic modelling for pricing contracts confirmed that "*we do actually model our assets versus liabilities to come up with any investment strategies but we do not have a model which combines both assets and liabilities together*". It seems that in practice the linkage between assets and liabilities is very limited. This is one of the drawbacks of traditional asset-liability models (Christofides, 2000).

A respondent to the postal DST/FCR survey commented that "*you should obtain interesting results in respect of with-profit offices. However, some responses from linked and non-profit offices may look rather negative*". It is a common perception that the results of DST investigations are deemed more important for with-profit offices than for their unit-linked counterparts due to the nature of the business. This was confirmed by the interview participants. When asked about whether the results of DST investigations ever led to the company taking any material measure in underwriting and investment operations, one interview participant from a with-profit office confirmed that "*along with other major with-profit offices, the results of solvency projections are very important*". These DST results usually affected company decisions about both underwriting and investment operations. In contrast, non-profit offices (e.g. unit-linked offices) all gave relatively negative responses to the same issue.

When asked about whether the results of DFA investigations ever led to the company taking any material measures in underwriting and investment operations, the two non-life interview participants gave different responses. One stated that DFA results affect underwriting decisions, whereas the other one investment decisions. This is probably because one of these two companies only used DFA to evaluate underwriting strategies, whereas the other firm only used DFA to evaluate investment strategies.

DFA modelling is first developed for solvency monitoring purposes to quantify the impact of the risks faced by a firm on the company's financial strength. Then it has been applied to a variety of internal management uses such as evaluation of reinsurance programmes and asset allocation. Over the years, it has been viewed as a powerful and flexible tool for solvency monitoring and internal management purposes. Based on a combination of company business plans and actuarial projections, a DFA model generally is used to forecast a firm's future performance under various scenarios both of macroeconomic conditions and of the insurance market by producing the simulated year-by-year cash flows. By so doing, analysts would be able to evaluate the impact of likely future economic conditions and of implementing different management strategies on the financial performance of the company and on the resilience of the firm to adverse external conditions. According to its uses described above, the main purposes of DFA are to gain insights into the risks faced by the company, and to select from among a variety of management strategies and, if possible, to identify optimal strategies for the conduct of the firm.

Since underwriting and investment operations are two main activities of an insurance company, DFA should be applied to underwriting and investment simultaneously rather than separately in order to assess the overall impact on insurer performance. Also, the changes in the value of an asset may vary in concert with insurance product experience and the dependencies between assets and liabilities should be considered in a DFA model. If DFA was only applied to one of the two operations, it might lead to biased projections of the overall performance of the insurer. Moreover, a number of economic factors have an impact on both underwriting and investment operations. For instance, inflation affects both claim severity (on the liability side) and yield curve (on the asset side). Failing to simultaneously take into account the effects of inflation on both two sides of the balance sheet would reduce variability of overall company performance. In order to incorporate significant dependencies between the liability and asset processes, a complete DFA model which combines both sides of an insurer's balance sheet would be required. It is worth noting that some dependencies are spurious and accordingly should be separated and ignored. Also, such a model should be an explanatory, causative, structural one which builds in known relationships and dependencies and that has volatility and randomness accounting for variability which is characteristic of insurance. The most important principle is that the totality of the company's operations is being considered.

How should DFA be used in the context of insurance? First of all, there should be a qualified actuary or other suitable expert within the insurance company or acting as a consultant. He or she should be able to develop a complete DFA model and exercise the necessary judgement when using the model in the circumstances of the particular company under a variety of market conditions. In general such a model is used to conduct various "what-if" analyses such as the testing of the solvency status and the evaluation of different management strategies. Based on the DFA results obtained, a report on the financial condition of the insurer should be prepared and presented to the Board. This report will be of particular interest not only to company management and those involved in developing business plan, but also to supervisory regulators.

A range of responses was obtained when interview participants were asked what factors limited the ability to use DST/DFA techniques. This reflects the diverse nature of the organisation represented. The responses also reflect that the resources were different within individual organisations. The responses included "*technology and data*", "*people and IT*", "*writing models and cost*", "*parameterisation of the model*" and "*company* *culture*". Lack of resources was a general response which could represent all the responses above, except the last one which will be discussed next in more detail.

Although non-life insurance is a highly technical business, the actuarial involvement in the non-life insurance industry is not as much as that in the life insurance industry. According to "The Actuarial Directory 2002", 38 per cent and 33 per cent of UK fellows work in pensions and life insurance industry respectively, whereas only eight per cent in non-life insurance industry. Many general insurance firms do not have actuaries probably because there are no statutory requirements and only relatively large non-life insurance companies have actuarial departments. In general, underwriters rely on their experience to underwrite policies. This was confirmed by one interviewee from a non-life insurance company who suggested that "*our department (actuarial department) has been in place only for one year*", going on to say that "*it is the culture of the organisation that we try to change. Try to show that we can work with the underwriters to improve the understanding of the risks*". It is worth noting that in practice underwriters sometimes use too much subjective judgement in underwriting. Using subjective judgement is not undesirable in itself, as long as it can help predict expected claims cost and other expenses.

Since GN2 is only recommended and not mandatory practice, not all of the life offices surveyed fully comply with it. Compared to non-profit offices (e.g. unit-linked offices), with-profit offices would find GN2 more relevant to their business and would be more willing to comply with it. This was confirmed by the interview participants. One with-profit office confirming that "we fully comply with GN2", whereas non-profit offices confirming that "*we comply with GN2 to the extent we need to*" and "*if GN2 becomes mandatory, we will have no problems with fully complying with it*".

When asked about what features of the DST techniques the company plans to improve in the near future, all organisations expressed a desire to work on stochastic modelling. This belief may have been influenced by the FSA's policy on encouraging insurance companies to conduct stochastic modelling and by increased business imperatives requiring more understanding of company financial strength and the effects of chosen strategies on company performance, which can make stochastic modelling an attractive option. Overall there seemed to be a general view that stochastic modelling was very much a tool which would be increasingly utilised in the insurance industry.

3. Financial Condition Reporting

All the life offices interviewed prepared FCRs in accordance with GN2. However, due to the nature of individual business the FCRs produced by these offices are different in terms of content. In general with-profit offices have more complicated FCRs than non-profit offices. The following are usually included in the FCR: main risks, solvency projections, results of sensitivity testing and scenario testing, commentaries on new business strategies, business volume and investment market, etc. When asked about the reasons for not producing FCR, one general insurer who did not produce FCR stated that *"we have other reports covering similar things"*.

The interview sought suggestions about improvements to GN2. Very different responses were obtained from the interviewees. One interviewee had no opinion about this. One implied that GN2 should provide more guidance on stochastic modelling. An unexpected response was obtained from the Appointed Actuary of a unit-linked office stating that "*I think GN2 should be thrown out...There is nothing in it which I find any use whatever would tell me or make me do anything different...Actuaries use their judgement to do whatever is appropriate to their offices*". The main reason why the Appointed Actuary made such a comment is because "*GN2 is very much geared to with-profit offices and to specific problems about assets and liabilities*". From the above results, GN2 could be improved in the following two ways. First, more guidance on stochastic modelling should be included in GN2. Since the FSA has recently been encouraging insurance companies to do stochastic modelling for the purpose of monitoring solvency, more and more insurers are developing their capability of carrying out stochastic work. Therefore, it may be helpful to provide more relevant guidance in GN2 for actuaries who are not familiar with stochastic modelling. Second, since GN2 was drafted mainly for with-profit offices, it would be desirable if a guidance note on FCR specifically for non-profit offices could be drafted.

When asked about whether it is necessary to introduce a Guidance Note on FCR specifically for non-life insurance companies, both non-life interviewees agreed that a relevant Guidance Note should be introduced, especially if it is mandatory to produce FCR. In addition, all interviewees confirmed that FCR is a worthwhile exercise and the FCR will be improved in some way in the coming years.

Since all interviewees are also the survey respondents to the surveys, it would give us an opportunity to compare and contrast the results from the interviews with the results from the surveys. In a sense comparing both results is exploring the validity of the surveys. Validity can take many forms and is usually divided into several types such as face validity, content validity, construct validity, internal and external validity. Each type addresses a specific methodological question. In the case of survey, validity, in its everyday sense, refers to the success of the survey in retrieving "valid" results. There are a number of sources of error that can have an adverse impact on the validity of the survey, such as non-respondent bias, coding errors and misunderstanding of the survey questions by the respondents. As stated in the research methods chapter, several measures were taken to ensure the validity of the survey, including the attempt to increase the response rate, the use of valid range checks and filter checks, and the pilot testing of the questions and the questionnaire. Although these approaches to obtaining valid survey results have been adopted, consideration was given to the various methods of exploring the validity of the survey. The preferred method would have been to investigate whether the survey is valid in terms of all these types of validity. This proved to be impossible, as data were not available which would facilitate such an investigation. This is because the interview programme is not originally intended as a means to validate the survey results. Thus, an alternative method was selected. This involved comparing the results from the two research methods, where possible.

Table 7.3 maps the interview responses onto the questionnaire based on the available characteristics. It should be noted that the mapping was only conducted for a number of categories due to the reason indicated above. These categories include *the techniques used, applications, number of risk categories included, importance rating, forecast period in DST, incorporation of DST/DFA results in decision making process, use of FCR, opinions about the introduction of a Guidance Note on FCR for general insurers, main reasons for not producing FCR.* The survey results shown in this table were obtained from the non-life and life postal surveys administered in May 2002. For most of these categories, it is self-evident that the interview responses are the same as those based on the survey data. However, there are two categories which may require a further explanation. The first is that at the interviews the interviewees were asked about the main risks faced by the company. For Companies A, B, and E, the factors associated with these risks were given highest importance ratings in the questionnaires. In the case of Company D, the Pricing Actuary with the company commented that:

"Pricing is imperative; CAT (catastrophe) risk management is also very important."

This quotation implies that the main focus of this company was underwriting operation. It is also noted that the determinant given the highest rating (5) by this Actuary is *stability of underwriting operation*. This suggests that in a sense the responses given by this Actuary are reliable.

Turning to Company C, *interest rate changes*, *interest rate level*, and *equity returns* are the performance determinants with highest ratings (5). Nevertheless, none of the risks associated with these determinants were confirmed at the interview with the Actuarial Manager of Company C. The inconsistent results indicate that the interviewee's responses are somewhat unreliable and should be treated with some caution.

The second category is that in the questionnaires the respondents were asked to indicate the extent to which the DFA/DST results are incorporated in the decision making process by senior management. It is noted that for Companies A, B, D and E, the larger extent these results are considered, the more likely these results have ever directly led to the company to take material measures in underwriting or investment operations. However, the Actuarial Manager with Company C indicated in the questionnaire that the DST result considerations are *always* involved in the decisions made by senior management, but at the interview he stated that such measures have never been taken. There are two possible reasons. The first is that the interviewee's survey and interview responses contradict each other. The second possible reason is that senior management of this company seems to be able to make decisions without recourse to DST.

On the whole, these results show that the interview responses generally are consistent with the survey. We are therefore able to conclude that the quantitative information collected in the postal survey is an accurate method of investigating the current DFA/DST/FCR practices. This finding implies that the survey results generally are valid and that overall the conclusions drawn from the surveys can be trusted. .

This validity analysis is subject to a number of caveats. There are only five companies interviewed and as a result, the comparison is unavoidably restricted. Also, the number of characteristics with which can be used to compare, such as the DFA/DST technique and risk categories used, is small because the interview programme is not designed to validate the survey results. Nevertheless, it is believed that comparing the results from the interviews, however few, with the results from the surveys would help validate that the responses obtained from the surveys stand up to deeper scrutiny.

Table 7.3: The comparison of the survey and interview results

Company Name	Survey results	Interview results
A	Techniques used: *sensitivity testing, scenario testing and stochastic simulation.*	Sensitivity testing and scenario testing are used extensively; stochastic simulation is only applied to certain business lines such as with-profit pension business.
	Applications: *Solvency testing, capital allocation, help develop business plan, pricing, asset allocation and communicate results with rating agencies. .*	Solvency testing (changes in equity market), capital allocation (with-profit business with guarantees), pricing (cost of guarantees), asset allocation (equities and bonds).
	Number of risk categories included: *10 (future investment con ditions, level of new business, interest rate level,*	Most of the above-mentioned risk categories are confirmed by the interviewee, such as changes in interest rates, and changes in equities.
	Importance rating*: *two determinants with highest ratings are interest rate level (5), and equity returns (5).*	The most significant risk is investment risk; the DST is focused on the changes in investment market.
	Forecast period in DST: *five years.*	The DST projection period is five years.
	Incorporation of DST results in decision making process: *usually.*	There have been some really important decisions taken as a result of the results of DST investigations.
B	Techniques used: *sensitivity testing, and scenario testing.*	The company mainly carries out sensitivity testing and has some limited scenario testing capability.
	Number of risk categories included: *7 (future investment conditions, persistency, equity returns, Interest rate level, etc).*	The company looks at things like falls in equity market in terms of future profit, not solvency risk, and elapse risk.
	Importance rating*: the only *determinant with highest rating is interest rate level (5).*	The main risks are interest rate risk and mortality risk.
	Incorporation of DST results in decision making process: *occasionally.*	The DST results have never directly led the company to take any material measure in underwriting or investment operations.

Note: *In the questionnaires the respondents were asked to rate the importance of the possible determinants on a five-point scale ("5" being most important).

Table 7.3: The comparison of the survey and interview results (continued)

Company Name	Survey results	Interview results
C	Techniques used: *only sensitivity testing.*	The company conducts some sensitivity testing, but not very much. It has not really looked at scenario testing and is only just starting to use stochastic techniques.
	Importance rating*: *three determinants with highest ratings are interest rate changes (5), interest rate level (5), and equity returns (5).*	For annuity business, the main risk is mortality risk; for unit-linked business, it would be expense and lapse risks.
	Forecast period in DST: *five years.*	The company uses a five-year projection period in DST.
	Incorporation of DST results in decision making process: *always.*	The DST results have never directly led the company to take any material measure in underwriting or investment operations.
D	Techniques used: *scenario testing and stochastic simulation.*	Stochastic modelling (pricing); scenario testing (reinsurance).
	Importance rating*: *the only determinant with highest ratings is stability of underwriting operations (5).*	The main risks the organisation faces include premium risk, reserving risk, credit risk, asset risk, investment risk, and operational risk.
	Incorporation of DFA results in decision making process: *usually.*	The DFA results have ever directly led the company to take material measures in underwriting operations.
	Use of FCR: *yes.*	Use of FCR: *yes; the company's FCR includes the main risk, and DFA results.*
	Opinions about the introduction of a Guidance Note on FCR for general insurers: *yes, it is necessary.*	The interviewee stated that it is necessary to introduce a Guidance Note for non-life insurance companies.

Note: *In the questionnaires the respondents were asked to rate the importance of the possible determinants on a five-point scale ("5" being most important).

Table 7.3: The comparison of the survey and interview results (continued)

Company Name	Survey results	Interview results
E	Techniques used: *sensitivity testing, scenario testing and stochastic simulation.*	The company conducts sensitivity testing, scenario testing and stochastic modelling.
	Importance rating*: *the only determinant with highest ratings is accuracy of reserve estimates (5).*	The risks the company faces are centred around the management of its liabilities.
	Incorporation of DFA results in decision making process: *often.*	The DFA results have ever directly led th e company to take material measures in investment operations.
	Use of FCR: *no.*	The company does not produce FCR.
	Opinions about the introduction of a Guidance Note on FCR for general insurers: *yes, it is necessary*	If it is mandatory to produce FCR, it would be essential to introduce a Guidance Note.
	Main reason for not producing FCR: *lack of need.*	The company has other reports covering things similar those in FCR.

Note: *In the questionnaires the respondents were asked to rate the importance of the possible determinants on a five-point scale ("5" being most important).

7.6 Summary and Conclusions

This chapter has described the findings of the interviews which were conducted with five of the postal survey respondents. These findings further enrich the results of the two postal surveys presented in the previous chapter. The interview evidence suggests that the risks faced by the sample firms were varied. Among these risks, investment risk is the most common main risk to most of the organisations interviewed, particularly with-profit life offices. For the unit-linked offices, expense and lapse risks are two major risks. A non-life insurer identified asbestos-related claims as the greatest threat to its solvency. For a given firm, the types of risks depend not only on the business it has transacted, but also on that it plans to do in the future.

All the interview insurers confirmed that conducting DFA/DST was important to them. Nonetheless, it appears that their use of DFA/DST techniques varied considerably. For those firms carrying out stochastic modelling, its use was very limited.

One of the contributions of the follow-up interviews has been to show that the interactions of assets and liabilities within the interview firms were in general restricted. One of these companies reporting conducting stochastic modelling stated that it did not have a model which combines both assets and liabilities together. It seems that in practice the linkage between assets and liabilities was very limited, which is a major drawback of traditional asset-liability models. This disadvantage has been removed in most modern DFA/DST models due to their emphasis on the interrelationships between items in the balance sheet.

It is a common perception that the results of DST investigations are deemed more important for with-profit offices than for their unit-linked counterparts due to the nature of the business. This was confirmed by the interview participants. In addition, because GN2 is not mandatory, not all the life offices interviewed fully comply with it. Compared with unit-linked or non-profit offices, with-profit offices would find GN2 more relevant to their business and would be more willing to comply with it. This was also confirmed by the interview participants.

The extent to which many of the sample companies were able to employ the DFA/DST techniques is constrained by the following factors. These include "*technology and data*", "*people and IT*", "*writing models and cost*", "*parameterisation of the model*" and "*company culture*". The evidence obtained from the interviews shows that although the sample companies were exposed to investment risk to a great extent, these factors limited their ability to use these techniques in order to reduce their investment risk exposure. In addition, since the FSA has been encouraging companies to develop stochastic models, all companies interviewed expressed a desire to work on it. Nevertheless, it seems that insurers generally are new to stochastic modelling, and accordingly more guidance on it is now required.

All the life offices interviewed prepared FCRs in accordance with GN2. In general with-profit offices have more complicated FCRs than non-profit offices. Both non-life interviewees agreed that a relevant Guidance Note should be introduced, especially if it is mandatory to produce FCR. All interview participants confirmed that FCR is a worthwhile exercise.

In order to explore the validity of the surveys, the comparison of a number of available characteristics of the sample companies based on the interview evidence with those based on the data obtained in the post surveys was made. This comparison suggests that the questionnaires provide a relatively accurate method of investigating the current DFA/DST/FCR practices. This finding implies that the survey results are valid, at least, to a certain extent.

This thesis thus far, has summarised the incidence and manner of usage of DFA/DST/FCR related techniques in the UK insurance industry. A large number of discoveries have been made. Additionally, evidence has been presented within this chapter which suggests that insurers relied heavily on actuaries' professional judgement to establish which risk factors should be tested and considered being included in DFA/DST applications. In general, none of statistical and econometric techniques was employed by practitioners to help identify these factors. It is suggested in this thesis that actuaries could practically improve their identification using panel data analysis.

Chapter eight of this thesis will now show how the analysis can be conducted and report its findings. The key performance determinants which actuaries should consider including in these applications will be presented and discussed.

Chapter Eight

The Determinants of Insurance Company Performance: Empirical Analyses

8.1 Introduction

As discussed in Chapter three, the first step in carrying out Dynamic Financial Analysis (DFA)/ Dynamic Solvency Testing (DST) is to investigate the risks faced by the company and the current DFA/DST practices. The empirical results have been presented and analysed in the previous two chapters. The second step is to identify the determinants of insurance company performance, i.e. the risk factors which have a material impact on company performance and that should be considered being included in DFA/DST applications. This step is important because regardless of the specific DFA/DST techniques used, DFA/DST modelling require an overall understanding of the business and the economic and firm-specific factors that affect the business. Many actuarial professional bodies have suggested that actuaries should take account of these risk factors in the application of a DFA model to a particular insurer. For instance, Guidance Note 2 (GN2) issued by the Faculty and Institute of Actuaries in 1996 suggests that actuaries should test variations in some assumptions and be alert to some risk factors when carrying out DST (Faculty and Institute of Actuaries, 1996). The Standard of Practice on Dynamic Capital Adequacy Testing issued by the Canadian Institute of Actuaries in 1998 also suggests that actuaries should take into account some risk categories when conducting Dynamic Capital Adequacy Testing (DCAT) (Canadian Institute of Actuaries, 1998).

In practice, actuaries identify the risk factors affecting company performance largely based on their professional judgement. Moreover, in order to double-check whether all the important factors are identified, actuaries also can investigate if the company is exposed to the risk factors listed by actuarial professional bodies. These risk factors have been discussed in Chapter two. Another way of finding out these determinants is to conduct a statistical empirical analysis, in which actuaries' professional judgement is still indispensable. The purpose of this chapter is twofold: (1) to demonstrate how the technique could be employed to decide on the performance determinants using two panel data sets consisting of economic and firm-specific data, and (2) to identify the factors affecting the performance of UK insurers during the period 1986-1999.

This chapter extends prior research and contributes to the literature on the performance determinants in a number of ways. First, a comprehensive research on performance determinants using both FSA/DTI returns and economic data has not yet been conducted on the UK insurance industry. As a result, this chapter can be used to fill the gap in the literature. Moreover, the majority of the empirical studies of insurer performance determinants are based on companies in the USA. It is therefore essential to explore further whether the performance of UK insurers is related to factors similar to those which appear to exert influence on the performance of US insurers. The results obtained can also be compared with the results of studies conducted in the insurance industry or other financial sectors across the world. Second, we address some econometric problems such as heteroskedasticity, multicollinearity and autocorrelation, which are sometimes ignored in applied work in the context of panel data analysis (See, for example, Swamy et al. (1996), Bennaceur & Goaied (2001) and Browne, Carson & Hoyt (2001)). Third, *investment yield* and *combined ratio*, the performance measures that have not been used in previous studies on performance determinants, are employed to capture the investment and underwriting performance of insurance firms respectively. Fourth, the study provides insights into the factors affecting the performance or financial strength of UK insurance companies. Fifth, the panel data design helps overcome some of the data and research method-based limitations (e.g. inability to control for unobservable differences across individual insurers that might influence company performance) encountered in previous cross-sectional research. Therefore, this research will be of interest to insurance regulatory authorities, company managers and actuaries.

There are a number of cautionary statements that should be made at the outset of this chapter. First, compared with other performance studies the results presented in this chapter are relatively unlikely to be subject to survivorship bias. This bias is a common one in ordinary performance studies. It results from the exclusion of failed companies from the data sets because of the fact that these companies no longer exist. Survivorship bias might cause the results to skew higher because only companies, which were successful enough to survive until the end of the period, are included. Nevertheless, the data sets used in this research include the insurers which had ever existed during the period 1986-1999 and had filed complete returns even if they failed to survive until 1999. Therefore, survivorship bias is relatively unlikely to occur in this study. Second, as indicated previously one of the purposes of this chapter is to demonstrate how the econometric technique could be used to decide on the determinants. The determinants are identified using annual data over the period of 1986-1999. Nonetheless, these determinants might change from one epoch to another. The results arising out of a specific period may reflect the features of that period. This is the case especially during a time of rapid changes in the insurance market place.

The remainder of this chapter is organised as follows. For convenience, Section 8.2 reiterates the research hypotheses formulated in Chapter four. Section 8.3 discusses some theoretical considerations of model building. Section 8.4 constructs the empirical framework of the model employed in the analyses. Sections 8.5 and 8.6 investigate the performance determinants of the UK non-life and life insurance industries respectively. Section 8.7 compares the results of this chapter with some of the survey findings of Chapter six. Section 8.8 summarises and concludes the chapter.

8.2 Research Hypotheses Revisited

The research hypotheses were formulated in Chapter four. For convenience, they are reiterated as follows:

Hypothesis 1: Other things being equal, it is expected that the relationship between performance and *unexpected inflation* would be negative for both non-life and life insurance companies.

Hypothesis 2: Other things being equal, it is expected that the relationship between performance and *interest rate changes* would be negative for life insurance companies, but there is no prior expectation about the direction of the relationship between performance and *interest rate changes* for non-life insurance companies.

Hypothesis 3: Other things being equal, it is expected that the relationship between performance and *interest rate level* would be positive for non-life insurance companies, but there is no prior expectation about the direction of the relationship between performance and *interest rate level* for life insurance companies.

Hypothesis 4: Other things being equal, it is expected that the relationship between performance and *equity returns* would be positive for non-life insurance companies, but there is no prior expectation about the direction of the relationship between performance and *equity returns* for life insurance companies.

Hypothesis 5: Other things being equal, it is expected that the relationship between performance and *company size* would be positive for both non-life and life insurance companies.

Hypothesis 6: Other things being equal, it is expected that the relationship between performance and *reinsurance dependence* would be negative for both non-life and life insurance companies.

Hypothesis 7: Other things being equal, it is expected that the relationship between performance and *leverage* would be negative for both non-life and life insurance companies.

Hypothesis 8: Other things being equal, it is expected that the relationship between performance and *affiliated investments* would be negative for non-life insurance companies.

Hypothesis 9: Other things being equal, it is expected that both the relationship between performance and *solvency margin* for non-life insurance companies, and the relationship between performance and *free asset ratio* for life insurance companies, would be positive.

Hypothesis 10: Other things being equal, there is no prior expectation about the direction of the relationship between performance and *stability of underwriting operation* for both non-life and life insurance companies.

Hypothesis 11: Other things being equal, it is expected that the relationship between performance and asset *liquidity* would be positive for both non-life and life insurance companies.

Hypothesis 12: Other things being equal, it is expected that the relationship between performance and *stability of asset structure* would be positive for both non-life and life insurance companies.

Hypothesis 13: Other things being equal, there is no prior expectation about the direction of the relationship between performance and *asset / product mix* variables for both non-life and life insurance companies.

8.3 Theoretical Considerations of Model Building

Several important issues need to be dealt with in specifying an empirical model. These include choice of suitable dependent and explanatory variables, measurement of these variables, choice of appropriate functional form and estimation techniques (see, for example, Studenmund (1997); Swamy et al. (1996)). The remainder of this section discusses the above-mentioned issues, except the issue of estimation techniques that has been addressed in Chapter five.

8.3.1 Choice of Dependent Variables and Their Measurement

In Chapter four, ten performance measures commonly seen in the insurance industry were discussed. Of these measures it was decided to use *investment yield, percentage change in shareholders' funds*, and *return on shareholders' funds* as performance measures in the empirical analyses for the non-life and life sectors. Additionally, *combined ratio* is also used as a performance measure in the analysis of the non-life sector. These measures are chosen based on the following criteria.

First, the values for the measures should be able to be calculated or obtained from the FSA/DTI returns. The reasons for using the FSA/DTI returns as the data source were presented in Chapter five. Second, measures should involve the minimum element of actuarial judgement because the assumptions made by actuaries could be different. Third, in order to compare the results of the empirical analyses of non-life and life sectors the measures chosen should be those frequently used in these two sectors. Fourth, since a significant proportion of the profit of insurance companies comes mainly from investment operations it seems appropriate to use an investment performance measure in the analyses. Nevertheless, since underwriting operation is the core business of non-life insurers, a performance measure which can capture underwriting performance should be used particularly in the non-life analysis. Fifth, in order to measure different aspects of insurance operations a range of performance measures are used. Finally, because the data used are statutory returns, which are submitted to the regulator for solvency monitoring purposes, it seems appropriate that the measures chosen should mainly focus on the financial strength of an insurer. Based on the above-mentioned criteria, the reasons for choosing or not choosing the performance measures are presented in Table 8.1.

Table 8.1: Reasons for choosing or not choosing a performance measure

Performance measure	Selected	Reason
Investment yield	*	• An investment performance related performance measure
Loss ratio		• Mostly used in non-life insurance industry
Expense ratio		• Mostly used in non-life insurance industry
Combined ratio	*	• A performance measure which can capture underwriting performance of non-life insurance companies
Overall operating ratio		• Mostly used in non-life insurance industry
Return on assets		• A similar measure, investment yield has been used. • Not focuses on the financial strength of an insurance company
Percentage change in shareholders' funds	*	• Solely focuses on the financial strength of an insurance company
Return on shareholders' funds	*	• Reflects profit made by an insurance company as well as its financial strength
Economic value added		• Cannot be calculated due to the unavailability of cost of capital from the FSA/DTI returns
Embedded value		• Involves too much actuarial judgement • Requires assumptions • Only very few companies publish embedded value.

The measurement of these four chosen performance measures described in Chapter four is reiterated for convenience purposes.

1. Investment yield

$$\text{Investment yield} = \{(\text{Net investment income})_t / [0.5*((\text{Adjusted total assets})_{t-1} + (\text{Adjusted total assets})_t)]\}*100\% \quad (8.3.1)$$

where

net investment income is investment income – investment management charges; adjusted total assets is total assets – (reinsurers' share of technical provisions + deferred acquisition costs).

2. Percentage change in shareholders' funds

Percentage change in shareholders' funds

$$= \{[(\text{Shareholders' funds})_{t} - (\text{Shareholders' funds})_{t-1}] / (\text{Shareholders' funds})_{t-1}\}*100\% \quad (8.3.2)$$

3. Return on shareholders' funds

$$\text{Return on shareholders' funds} = \{(\text{Profit before tax}) / [0.5*((\text{Shareholders' funds})_{t-1} + (\text{Shareholders' funds})_{t})]\}*100\% \quad (8.3.3)$$

where

profit before tax is the sum of underwriting profit, net investment income, net realised gains, and other income.

4. Combined ratio

$$\text{Combined ratio} = (\text{Loss ratio}) + (\text{Expense ratio}) \quad (8.3.4)$$

where

$$\text{Loss ratio} = [(\text{Incurred losses} + \text{Claim management expenses}) / (\text{Premiums earned})]*100\% \quad (8.3.5)$$

and

$$\text{Expense ratio} = [\text{Expenses} / (\text{Premiums written})]*100\% \quad (8.3.6)$$

As discussed in Chapter four, a *combined ratio* of less than 100 per cent indicates that the company is generating underwriting profit. A company with a low *combined ratio* outperforms one with a high *combined ratio*. Therefore, the hypothesised relationships between performance and explanatory variables in the previous section should be reversed when the *combined ratio* is used as the performance measure.

It is worthwhile to reiterate the main reason why several performance measures are used in this research. Since insurance operations are complex any performance measure would only be able to capture one aspect of company performance. Therefore, with a view to having a general picture of company performance it was decided to utilise four different measures for the non-life sector and three for the life sector. Moreover, if a statistically significant relationship can be found in the models for different performance measures, we can be relatively confident of this relationship. In a sense, this is also one of the forms of "triangulation".

8.3.2 Choice of Explanatory Variables and Their Measurement

The choice of explanatory variables is based on their theoretical relationship with the dependent variable. Generally speaking, the chosen explanatory variables are expected to partly explain the variation of the dependent variable. In this chapter, we take into account both economic and firm-specific variables which might affect the performance of UK insurance companies. It should be noted that not all the explanatory variables are included in the models for both non-life and life insurance sectors due to the availability of the data. Moreover, the measurement of one variable could be slightly different because of different characteristics of these sectors. These explanatory variables and their measurement are as follows:

1. Economic variables

(1) *Unexpected inflation*

The variable *unexpected inflation* (UI) is measured as the UK inflation rate minus interbank one-year middle rate. A similar measure is used in Browne & Hoyt (1995).

(2) *Interest rate changes*

The variable *interest rate changes* (IRC) is measured as the difference in the UK three-month Treasury bill middle rate between the current year and the prior year.

(3) *Interest rate level*

The variable *interest rate level* (IRL) is measured by the UK ten-year government bond yield.

(4) *Equity returns*

The variable *equity returns* (ER) is measured by the FTSE All Share- total return index.

2. Firm-specific variables

(1) *Company size*

This variable is measured as the natural logarithm of total assets (LOGTA).

(2) *Reinsurance dependence*

This variable is measured as reinsurance ceded divided by total assets (RCTA). A similar measure is used in Browne, Carson, and Hoyt (2001).

(3) *Leverage*

In the empirical analysis for non-life insurers, *leverage* is measured as total net technical provisions divided by shareholders' funds (TNTPSF). A similar measure is used in Adams and Buckle (2000) and Browne, Carson and Hoyt (2001). In the empirical analysis for life insurers, this variable is measured as total reserve divided by shareholders' funds (TRSF).

(4) *Affiliated investments*

This variable is measured as total affiliated investments divided by shareholders' funds (TAISF).

(5) *Solvency margin* or *free asset ratio*

Solvency margin is often used in the non-life insurance industry and is measured as net assets divided by net premiums written (NANPW). Its counterpart in the life insurance sector is *free asset ratio* and is measured as excess (deficiency) of available assets and implicit items over the required minimum margin divided by long-term business admissible assets.

(6) *Stability of underwriting operation*

In the analysis of the general insurance industry, *stability of underwriting operation* is measured as the difference of net premiums written between the current year and the prior year divided by net premiums written in the prior year (annual change in net premiums written, ACNPW). In the study of the life insurance industry, this variable is measured as the difference of net premiums earned between the current year and the prior year divided by net premiums earned in the prior year (annual change in net premiums earned, ACNPE). The *lower* the value of ACNPW or ACNPE, the *more* stable the underwriting operation.

(7) *Liquidity*

In the non-life analysis, *liquidity* is measured as total liabilities divided by liquid assets (TLLA); in the life study this variable is measured as total liabilities and margins divided by liquid assets (TLMLA). Liquid assets include cash, bonds and equities & other shares. The *lower* the value of TLLA, the *more* liquid the company's assets.

(8) *Stability of asset structure*

This variable is measured as the average of the absolute values of the percentage changes in nine different asset accounts (CAM). The nine asset accounts include property, cash, bonds, equities & other shares, affiliated investment, insurance debts, other assets, prepayments & accrued income and reinsurers' share of technical provisions. The *lower* the value of CAM, the *more* stable the asset structure.

(9) *Assets held to cover linked liabilities*

This variable is measured as assets held to cover linked liabilities divided by total admissible assets (AHCLLTA).

(10) *Product mix*

Five variables serve as proxies for product mix. These variables are life & general annuity reserve to total reserve (LGARTR), pension reserve to total reserve (PRTR), permanent health reserve to total reserve (PHRTR), other reserve to total reserve (ORTR), and unspecified additional reserve to total reserve (UARTR).

8.3.3 Choice of Functional Form

Theory and literature seldom suggest a particular functional form for the empirical model. Studenmund (1997) argues that the linear form should be used until strong evidence is found that this is inappropriate. Moreover, empirical models of linear form have been extensively used in the literature on identifying performance determinants (see, for example, Swamy et al. (1996); Bennaceur and Goaied (2001); Browne, Carson and Hoyt (2001)). In this chapter, we follow the previous studies and use linear functional form.

8.4 Empirical Framework

In order to obtain as much information as possible from the panel data sets, several possible regression specifications and feasible estimation techniques are used. For convenience, the general form of the empirical models discussed in Chapter five is re-specified as follows:

$$y_{it} = \alpha_i + \sum_{k=1}^{K} \beta_k x_{kit} + \varepsilon_{it} \tag{8.4.1}$$

where

y_{it} is the value of the performance measure for company i at time t.

x_{kit} is the value of the k*th* explanatory variable for company i at time t.

k is the index of explanatory variables and k = 1, …., K.

i is the index of company and i = 1, …., N.

t is the index of time periods and t = 1, …., T.

α_i and β_k are parameters to be estimated.

ε_{it} is the error component for company i at time t and is assumed to have mean zero, $E[\varepsilon_{it}]=0$ and constant variance $E[\varepsilon_{it}^2]= \sigma_\varepsilon^2$.

In the regression model specified above, intercept terms are assumed to vary across companies, but slope coefficients are assumed to be constant. α_i is time-invariant and accounts for an individual company effect that is not included in the regression (Baltagi, 1995). The heterogeneity across insurers that can not be explained by explanatory variables is assumed to be captured by intercept variation. There are, at least, two reasons for not allowing variation in slopes in our empirical models. First, the scope for analysing slope heterogeneity is limited when the number of time periods (only 14-year annual data available) is relatively small compared with the number of insurers. Second, the long-run equilibrium responses are less likely to be subject to slope variation than short-run adjustment pattern across companies (Pesaran, Smith & Im, 1996). In addition, a dynamic panel model including a lagged dependent variable is not specified in this research because the observations in the unbalanced panel are not consecutive in time due to the unavailability of part of the data.

The time effect is not included in the model because the panel data sets are short and economic variables in this research do not vary across the companies in a given period. Therefore, adding time effect dummies in the model would only create serious econometric problems.

There are three regression specifications employed in this chapter, including ordinary least squares regression model, one-factor fixed-effects model and one-factor random-effects model. The one-factor fixed-effects model is estimated by partitioned ordinary least squares without overall constant, whereas the one-factor random-effects model is estimated by feasible two-step generalised least squares (Greene, 1998). As previously stated, if a statistically significant relationship exists in all or most of the three regression specifications for a performance measure, we can therefore be relatively confident of this relationship. All the models are estimated using LIMDEP (Version 7.0)[1].

The main difference among the three models is the assumption about the intercept term α_i. In ordinary least square regression model, α_i is assumed to be the same across insurers. In one-factor fixed-effects model, α_i is assumed to vary across companies, but to be constant over time t. In one-factor random-effects model, α_i is assumed not only to vary across insurers, but also to be a random variable with zero mean and constant variance.

It would be desirable to know which of the above-mentioned three estimated models for each of performance measures is the most appropriate. A number of issues and statistical tests about the choice among the models have been suggested in the literature reviewed in Chapter five.

[1] LIMDEP is a product of Econometric Software, Inc.

8.5 Empirical Analysis of the Non-Life Insurance Industry

8.5.1 The Data

Identification of the determinants of non-life insurer performance is conducted using annual data over the period of 1986-1999. The data for performance measures and firm-specific variables are computed using the FSA/DTI returns from SynThesys Non-Life (Version 3.32), while the data on the economic variables are obtained from Datastream.

There are 346 non-life insurance firms in the data set SynThesys Non-life. Nevertheless, because this research is only focused on the UK non-life insurance market eight companies submitting global returns are excluded from this research.

Moreover, if a non-life insurance company fails to file statutory returns to the supervisory authority or files incomplete returns making the calculations of the performance measures or firm-specific variables impossible, it is excluded from the panel. Newly established non-life insurance companies are included in the panel from the year it was established. The final panel data set consists of 1,922 company-year observations for 211 general insurers over 14 years.

Tables 8.2 and 8.3 present descriptive statistics and the correlation matrix for the sample firms respectively. It is noted that the correlation coefficients between the firm-specific variables are very small. This reflects one of the main advantages of using panel data- the reduction in collinearity among the explanatory variables. However, the absolute values of the correlation coefficients between two economic variables are in general greater than those among these firm-specific variables. In particular, the absolute value of the correlation coefficient between *interest rate level* and *equity returns* is 0.91.

Table 8.2: Descriptive statistics of dependent and explanatory variables (Non-life)

Variable	Mean	Standard deviation	Minimum	Maximum	Median	Skewness	Kurtosis
IY	5.45	2.62	4.45	14.69	5.43	−0.17	1.40
PCSF	16.44	67.97	-686.30	739.11	7.37	1.73	30.02
RSF	0.78	72.24	−1423.73	370.70	7.65	-8.54	131.63
CR	174.55	1036.35	−17342.86	16741.67	109.55	4.00	140.88
UI	−4.92	1.37	7.56	−3.34	−4.57	−0.64	−1.02
IRC	−0.42	1.88	4.61	2	0.16	−0.71	−0.36
IRL	8.62	1.81	5.08	11.80	9.06	−0.36	−0.53
ER	6800.51	3733.27	2406.92	14904.31	4967.84	0.83	−0.55
LOGTA	11.44	1.47	7.88	14.90	11.45	0.03	−0.68
RCTA	10.30	8.48	−11.31	35.49	8.76	0.69	−0.26
TNTPSF	274.52	573.70	−7001.04	7433.15	182.13	2.60	74.46
TAISF	9.23	23.79	−69.03	158.37	0	3.27	11.55
NANPW	1961.83	20846.65	−243941.51	252400	275.65	3.22	66.41
ACNPW	5.64	155.33	−2100	1702.56	4.16	−0.30	64.75
TLLA	106.89	66.44	3.62	1045.48	98.09	5.55	54.66
CAM	2.57	1.65	0.06	8.23	2.10	1.13	0.86

Table 8.3: Correlation matrix for dependent and explanatory variables (Non-life)

Variable	PCSF	RSF	IY	CR	UI	IRC	IRL	ER	LOGTA
PCSF	1.00	0.16	0.11	0.00	–0.10	0.05	0.08	–0.09	–0.04
RSF	0.16	1.00	0.17	–0.05	–0.03	0.10	–0.04	0.05	0.04
IY	0.11	0.17	1.00	–0.01	–0.06	0.04	0.20	–0.15	–0.03
CR	0.00	–0.05	–0.01	1.00	0.03	–0.01	–0.06	0.06	–0.05
UI	–0.10	–0.03	–0.06	0.03	1.00	–0.23	–0.37	0.53	0.18
IRC	0.05	0.10	0.01	–0.01	–0.23	1.00	0.12	–0.06	–0.01
IRL	0.08	–0.04	0.21	–0.06	–0.37	0.12	1.00	–0.91	–0.17
ER	–0.09	0.05	–0.15	0.06	0.53	–0.06	–0.91	1.00	0.19
LOGTA	–0.04	0.04	–0.03	–0.05	0.18	–0.01	–0.17	0.19	1.00

	PCSF	RSF	IY	CR	UI	IRC	IRL	ER	LOGTA
RCTA	0.01	–0.02	–0.04	–0.07	–0.16	–0.06	0.22	–0.24	–0.07
TNTPSF	–0.04	–0.05	–0.01	0.05	0.01	0.02	–0.02	0.03	0.17
TAISF	–0.01	0.03	–0.01	–0.03	0.01	–0.02	0.03	–0.02	0.30
NANPW	0.03	–0.00	–0.03	0.46	0.02	0.02	–0.08	0.09	–0.04
ACNPW	0.06	0.12	0.05	–0.01	–0.05	0.00	0.09	–0.10	–0.02
TLLA	–0.15	–0.19	–0.39	0.03	0.03	–0.05	0.03	–0.03	0.14
CAM	0.09	–0.01	0.11	0.01	0.00	–0.01	0.10	–0.09	–0.14

	RCTA	TNTPSF	TAISF	NANPW	ACNPW	TLLA	CAM
LOGTA	–0.07	0.17	0.30	–0.04	–0.02	0.14	–0.14
RCTA	1.00	–0.09	–0.03	–0.08	0.08	0.01	0.12
TNTPSF	–0.09	1.00	0.03	0.04	0.00	0.15	–0.06
TAISF	–0.03	0.03	1.00	0.02	–0.03	0.19	–0.02
NANPW	–0.07	0.04	0.02	1.00	–0.02	0.06	–0.02
ACNPW	0.08	0.00	–0.03	–0.02	1.00	–0.13	0.06
TLLA	0.01	0.15	0.19	0.06	–0.13	1.00	–0.09
CAM	0.12	–0.06	–0.02	–0.02	0.06	–0.09	1.00

8.5.2 Empirical Results

The empirical analysis of performance determinants is conducted based on 1,922 company-year data from 1986 through 1999 for 211 UK non-life insurers. Ordinary least squares regression model, one-factor fixed-effects model and one-factor random-effects model are used to estimate each of these four performance measures, *investment yield*, *percentage change in shareholders' funds*, *return on shareholders' funds* and *combined ratio*. Moreover, statistical significance tests about the direction of the relationship between performance measures and explanatory variables are performed.

An upper-tail test is carried out if the predicted sign of the relationship is "+"; a lower-tail test is performed if the predicted sign of the relationship is "–"; a two-tail test is performed if there is no predicted sign. The empirical results are reported in Tables 8.4, 8.5, 8.6, and 8.7.

It is worthwhile to note that two levels of significance, 0.05 and 0.01, are chosen in the analyses of this thesis. Choosing the 0.05 (0.01) level of significance means that we require to be 95 per cent (99 per cent) confident of a relationship. For illustrative purposes, we use the 0.05 level of significance as an example to explain how decisions regarding statistical significance tests are made.

Case I: If the predicted sign is "+" and the following estimated results are obtained

(i) Coefficient = +3.21, t = 1.65, p-value (one-tail) = 0.04945, then the null hypothesis can be rejected.

(ii) Coefficient = +3.21, t = 1.39, p-value (one-tail) = 0.0823, then the null hypothesis cannot be rejected.

(iii) Coefficient = –3.21, t = –9.16, p-value (one-tail) = 0.0000, then the null hypothesis cannot be rejected. That is, any negative outcome provides no evidence against the null hypothesis.

Case II: If the predicted sign is "–" and the following estimated results are obtained

(i) Coefficient = –3.21, t = –1.65, p-value (one-tail) = 0.04945, then the null hypothesis can be rejected.

(ii) Coefficient = –3.21, t = –1.39, p-value (one-tail) = 0.0823, then the null hypothesis cannot be rejected.

(iii) Coefficient = +3.21, t = +9.16, p-value (one-tail) = 0.0000, then the null hypothesis cannot be rejected. That is, any positive outcome provides no evidence against the null hypothesis.

Case III: If there is no predicted sign and the following estimated results are obtained

(i) Coefficient = ±3.21, t = ±2.03, p-value (two-tail) = 0.0424, then the null hypothesis can be rejected.

(ii) Coefficient = ±3.21, t = ±1.93, p-value (two-tail) = 0.0534, then the null hypothesis cannot be rejected.

Table 8.4: Alternative regression specifications for investment yield (IY) (Non-life)

Explanatory variable	Predicted sign	Ordinary least squares regression model	One-factor fixed-effects model	One-factor random-effects model
Intercept		−1.37		−0.32
		(−1.22)		(−0.28)
UI	–	−0.80E−01	−0.68E−01	−0.93
		(−1.68)*	(−1.69)*	(−2.24)*
IRC		−0.43E−01	−0.27E−01	−0.38E−01
		(−1.33)	(−1.14)	(−1.56)
IRL	+	0.68	0.64	0.67
		(8.63)**	(10.52)**	(10.92)**
ER	+	0.19E−03	0.19E−03	0.19E−03
		(4.93)**	(6.27)**	(5.84)**
LOGTA	+	0.76E−01	−0.28	−0.33E−01
		(1.88)*	(−2.44)	(−0.52)
RCTA	–	−0.25E−01	−0.26E−01	0.30E 01
		(−3.51)**	(−3.11)**	(−4.22)**
TNTPSF	–	0.20E−03	0.59E−04	0.11E−03
		(1.62)	(0.59)	(1.23)
TAISF	–	0.47E−02	−0.48E−02	−0.21E−02
		(1.90)	(−1.43)	(−0.75)
NANPW	+	0.29E−06	0.21E−05	0.19E−05
		(0.11)	(1.30)	(0.89)
ACNPW		−0.30E−03	−0.86E−04	−0.10E−03
		(−0.63)	(−0.30)	(−0.36)
TLLA	–	−0.16E−01	−0.90E−02	0.11E 03
		(−9.16)**	(−7.48)**	(−12.65)**
CAM	–	0.11	0.47E−01	0.50E−01
		(3.08)	(1.61)	(1.76)
Number of observations		1922	1922	1922
Adjusted R-Square		0.22	0.52	
F test		46.34	10.28	
		[0.00]	[0.00]	
LM test				934.78
				[0.00]
Hausman test				54.32
				[0.00]

Notes:
1. t statistics are in parenthesis.
2. p values are in brackets.
3. An upper-tail test is performed if the predicted sign is "+"; a lower-tail test is performed if the predicted sign is "–"; a two-tail test is performed if there is no predicted sign.
4. * Significant at the 0.05 level; **significant at the 0.01 level.
5. Based on the results of LM test and Hausman test, we would conclude that of the three alternative regression specifications, the one-factor fixed-effects model is the better choice.

Table 8.5: Alternative regression specifications for percentage change in shareholders' funds (PCSF) (Non-life)

Explanatory variable	Predicted sign	Ordinary least squares regression model	One-factor fixed-effects model	One-factor random-effects model
Intercept		20.33 (0.62)		23.80 (0.64)
UI	–	−2.60 (−1.83)*	−2.86 (−2.13)*	−2.67 (−1.83)*
IRC		1.00 (1.35)	0.52 (0.72)	0.82 (0.95)
IRL	+	−0.65 (−0.26)	0.10 (0.04)	−0.47 (−0.22)
ER	+	−0.16E−02 (−1.26)	−0.20E−02 (−1.73)	−0.18E−02 (−1.54)
LOGTA	+	0.83 (0.77)	4.01 (1.19)	1.41 (0.78)
RCTA	–	−0.15 (−0.81)	−0.94 (−4.09)**	−0.45 (−1.96)
TNTPSF	–	−0.22E−02 (−0.53)	−0.13E−01 (−2.19)*	−0.78E−02 (−2.62)**
TAISF	–	0.37E−01 (0.63)	0.17 (1.89)	0.81E−01 (0.89)
NANPW	+	0.14E−03 (1.97)**	0.18E−03 (2.41)**	0.17E−03 (2.27)*
ACNPW		0.14E−01 (1.35)	0.34E−02 (0.33)	0.74E−02 (0.73)
TLLA	–	−0.15 (−4.52)**	−0.26 (−5.17)**	−0.20 (−6.72)**
CAM	–	3.06 (2.71)	2.98 (2.52)	3.19 (3.22)
Number of observations		1922	1922	1922
Adjusted R-Square		0.04	0.09	
F test		7.50 [0.00]	1.86 [0.00]	
LM test				0.08 [0.77]
Hausman test				41.94 [0.00]

Notes:
1. t statistics are in parenthesis.
2. p values are in brackets.
3. An upper-tail test is performed if the predicted sign is "+"; a lower-tail test is performed if the predicted sign is "–"; a two-tail test is performed if there is no predicted sign.
4. * Significant at the 0.05 level; **significant at the 0.01 level.
5. Based on the results of LM test and Hausman test, we would conclude that of the three alternative regression specifications, the ordinary least squares regression model is the better choice.

Table 8.6: Alternative regression specifications for return on shareholders' funds (RSF) (Non-life)

Explanatory variable	Predicted sign	Ordinary least squares regression model	One-factor fixed-effects model	One-factor random-effects model
Intercept		–36.69		–35.33
		(–0.93)		(–0.98)
UI	–	–2.49	–3.36	–2.73
		(–1.35)	(–1.58)	(–1.85)*
IRC		3.17	2.78	3.04
		(4.01)**	(4.26)**	(3.48)**
IRL	+	0.53	1.31	0.78
		(0.21)	(0.55)	(0.35)
ER	+	0.16E–02	0.14E–02	0.16E–02
		(1.28)	(1.34)	(1.32)
LOGTA	+	3.01	3.81	2.97
		(2.50)**	(1.08)	(1.92)*
RCTA	–	–0.54E–01	–0.52	–0.19
		(0.22)	(–1.29)	(–0.84)
TNTPSF				
TAISF				
NANPW	+	0.22E–04	0.45E–04	0.32E–04
		(0.43)	(0.87)	(0.42)
ACNPW		0.48E–01	0.26E–01	0.41E–01
		(1.29)	(1.27)	(4.03)**
TLLA	–	–0.20	–0.26	–0.21
		(–3.24)**	(–2.46)*	(–7.65)**
CAM	–	–0.68	–1.21	–1.00
		(–0.69)	(1.09)	(–1.01)
Number of observations		1922	1922	1922
Adjusted R-Square		0.06	0.16	
F test		12.96	2.65	
		[0.00]	[0.00]	
LM test				49.15
				[0.00]
Hausman test				31.17
				[0.00]

Notes:

1. t statistics are in parenthesis.
2. p values are in brackets.
3. An upper-tail test is performed if the predicted sign is "+"; a lower-tail test is performed if the predicted sign is "–"; a two-tail test is performed if there is no predicted sign.
4. * Significant at the 0.05 level; **significant at the 0.01 level.
5. TNTPSF and TAISF are not included in the models, because the two explanatory variables and RSF have the same denominator.
6. Based on the results of LM test and Hausman test, we would conclude that of the three alternative regression specifications, the one-factor fixed-effects model is the better choice.

Table 8.7: Alternative regression specifications for combined ratio (CR) (Non-life)

Explanatory variable	Predicted sign	Ordinary least squares regression model	One-factor fixed-effects model	One-factor random-effects model
Intercept		744.47		1280.99
		(1.37)		(2.54)*
UI	+	10.46	48.76	25.05
		(0.51)	(2.29)*	(1.29)
IRC		–8.23	2.36	–2.41
		(–0.80)	(0.24)	(–0.21)
IRL	–	–26.18	–41.29	–32.55
		(–0.78)	(–1.34)	(–1.12)
ER	–	–0.79E–02	0.67E–02	–0.25E–02
		(0.37)	(0.32)	(–0.16)
LOGTA	–	–25.81	–198.66	–71.33
		(–1.54)	(–2.58)**	(–2.84)**
RCTA	+	3.73	5.85	0.27
		(1.74)*	(1.77)*	(0.08)
TNTPSF	+	0.73E–01	0.72E–01	0.74E–01
		(1.02)	(0.82)	(1.87)*
TAISF	+	–1.37	1.80	0.56
		(–1.18)	(0.49)	(0.45)
NANPW	–	0.23E–01	0.21E–01	0.22E–01
		(3.54)	(3.95)	(21.70)
ACNPW		–0.29E–02	0.11	0.65E–01
		(–0.03)	(0.74)	(0.48)
TLLA	+	0.77E–01	0.42	0.25
		(0.23)	(0.80)	(0.64)
CAM	+	12.41	20.07	15.29
		(1.38)	(2.03)*	(1.15)
Number of observations		1922	1922	1922
Adjusted R-Square		0.21	0.30	
F test		44.17	4.72	
		[0.00]	[0.00]	
LM test				19.29
				[0.00]
Hausman test				30.84
				[0.00]

Notes:
1. t statistics are in parenthesis.
2. p values are in brackets.
3. An upper-tail test is performed if the predicted sign is "+"; a lower-tail test is performed if the predicted sign is "–"; a two-tail test is performed if there is no predicted sign.
4. *Significant at the 0.05 level; **significant at the 0.01 level.
5. Based on the results of LM test and Hausman test, we would conclude that of the three alternative regression specifications, the one-factor fixed-effects model is the better choice.

It should be noted that not all the explanatory variables are included in the models for all four performance measures. *Leverage* (TNTPSF) and *affiliated investments* (TAISF) are not included in the models for *return on shareholders' funds*, because the two explanatory variables and *return on shareholders' funds* have the same denominator. By so doing, we can avoid false significance of some explanatory variables simply resulting from the same denominator.

In addition, multicollinearity, heteroskedasticity and autocorrelation are three common econometric problems in ordinary regression analysis, but they are usually ignored in applied work in the context of panel data analysis. We will show how these problems are addressed.

- Multicollinearity

The first econometric problem to be addressed in this study is multicollinearity. Multicollinearity means a linear correlation between two or more explanatory variables. The problem with multicollinearity is that the standard errors of the estimators of regression parameters tend to be large. There are four main consequences of multicollinearity. The first is that confidence intervals for regression parameters may be wide and estimates of regression parameters will be relatively imprecise. Second, computed t-statistics tend to decrease due to the increase in standard errors of the estimated coefficients. Thus, significance tests concerning individual explanatory variables may be misleading because variables with low t-statistics may be dropped from the regression when in fact these variables should be included. Third, it may be difficult to disentangle the individual impact of explanatory variables on the dependent variable. Finally, estimated coefficients will become very sensitive to changes in regression specification. Nevertheless, it should be noted that estimated coefficients remain unbiased even when there is a high degree of multicollinearity (Studenmund, 1997; Thomas, 1997).

The phenomenon of multicollinearity is usually unavoidable if several economic variables are included in the models because of the interrelationship between these variables. The fairly high degree of correlation between *interest rate level* and *equity returns* shown in Table 8.3 indicates that there is potential for multicollinearity in the estimation of the models for the four performance measures. It should be noted that multicollinearity could involve linear relationships between more than two explanatory variables and these relationships can not be detected by looking at simple correlation coefficients (Thomas, 1997). To give a formal indication of the severity of multicollinearity resulting from linear relationships between all variables, the values of Variance Inflation Factor (VIF) for each of the explanatory variables are calculated by running ordinary least square regressions. One of the explanatory variables (e.g. X_1 in formula (8.5.1)) serves as the dependent variable while the rest serve as the independent variables. The ordinary least square regression can be illustrated as follows:

$$X_1 = \alpha_1 + \alpha_k \sum_{k=2}^{K} X_k + \varepsilon_1 \tag{8.5.1}$$

where

X: explanatory variable

α: coefficient

K: the number of explanatory variables

ε: stochastic error term

The VIF_1 associated with X_1 is defined as

$$VIF_1 = \frac{1}{1 - R_1^{\ 2}} \tag{8.5.2}$$

where R_1 is the coefficient of multiple determination when the variable X_1 is regressed on all the other explanatory variables.

Table 8.8 shows that all variables have very small VIFs, except *interest rate level* and *equity returns*. Their VIF values are 6.92 and 8.32, respectively.

Table 8.8: Variance inflation factor for explanatory variables (Non-life)

Explanatory variable	Variance inflation factor
UI	1.72
IRC	1.16
IRL	6.92
ER	8.32
LOGTA	1.22
RCTA	1.10
TNTPSF	1.06
TAISF	1.14
NANPW	1.02
ACNPW	1.04
TLLA	1.10
CAM	1.05

The correlated variables would be more likely to become insignificant and accordingly it would be difficult to distinguish the individual effects of the correlated variables. In the empirical analysis, *interest rate level* and *equity returns* are significant in the models for *investment yield*, but insignificant in most of the models for *percentage change in shareholders' funds*, *return on shareholders' funds*, and *combined ratio*. It is therefore necessary to further explore the effects of multicollinearity on the models for these three performance measures. However, there is absolutely no need to consider taking any action to deal with possible effects of multicollinearity on the models for *investment yield* because both *interest rate level* and *equity returns* remain highly significant even in the presence of multicollinearity. In fact, we should not worry too much about the phenomenon of multicollinearity if regression equations have high t ratios (Studenmund, 1997). Even in the presence of severe multicollinearity, the ordinary least square estimators still retain all the desirable properties (Thomas, 1997).

There are a few possible remedies for multicollinearity. Since the severity of multicollinearity can change from sample to sample, obtaining more data seems to be one of the possible remedies. Nevertheless, due to the availability of data it is not feasible to increase the sample size for this research.

It has been also suggested in many econometric texts that doing nothing could be best remedy for researchers faced with multicollinearity because any other remedy could create other serious econometric problems (see, for example, Studenmund (1997); Kennedy (1998)). In addition, dropping one of the two highly correlated variables is a possible remedy for multicollinearity in the models for *percentage change in shareholders' funds*, *return on shareholders' funds*, and *combined ratio*. It was decided to drop *equity returns* instead of *interest rate level* because not only the former has the highest VIF value but also the latter has a stronger theoretical relationship with performance than the former due to the high proportion of bonds in the asset mix of non-life insurers. Dropping *equity returns* in the models for *percentage change in shareholders' funds* and *combined ratio* does make the estimated coefficients of *interest rate level* become significant and have expected sign, while the significance of other variables remain unchanged (Tables 8.9 and 8.10). Nevertheless, dropping *equity returns* in the models for *return on shareholders' funds* does not lead to the estimated coefficients of *interest rate level* becoming significant. Therefore, it would be wise to keep both *interest rate level* and *equity returns* in the models for *return on shareholders' funds* to avoid possible specification bias.

Table 8.9: Alternative regression specifications for percentage change in shareholders' funds (PCSF) (Non-Life)

Explanatory variable	Predicted sign	Ordinary least squares regression model	One-factor fixed-effects model	One-factor random-effects model
Intercept		−18.12		−18.77
		(−1.15)		(−0.75)
UI	–	−3.61	−4.01	−3.79
		(−2.83)**	(−3.15)**	(−3.01)**
IRC		0.70	0.18	0.49
		(0.89)	(0.24)	(0.59)
IRL	+	2.01	3.30	2.52
		(2.33)**	(3.20)**	(2.59)**
ER				
LOGTA	+	0.80	3.46	1.29
		(0.74)	(1.05)	(0.71)
RCTA	–	−0.14	−0.90	−0.43
		(−0.75)	(−3.93)**	(−1.85)
TNTPSF	–	−0.22E−02	−0.13E−01	−0.77E−02
		(−0.53)	(−2.19)*	(−2.60)**
TAISF	–	0.38E−01	0.18	0.83E−01
		(0.65)	(1.91)	(0.92)
NANPW	+	0.14E−03	0.18E−03	0.16E−03
		(1.93)*	(2.35)**	(2.19)*
ACNPW		0.14E−01	0.41E−02	0.80E−02
		(1.39)	(0.40)	(0.79)
TLLA	–	−0.15	−0.26	−0.20
		(−4.53)**	(−5.20)**	(−6.71)**
CAM	–	3.07	3.02	3.22
		(2.72)	(2.54)	(3.24)
Number of observations		1922	1922	1922
Adjusted R-Square		0.04	0.09	
F test		8.02	1.85	
		[0.00]	[0.00]	
LM test				0.11
				[0.74]
Hausman test				41.58
				[0.00]

Notes:

1. t statistics are in parenthesis.
2. p values are in brackets.
3. An upper-tail test is performed if the predicted sign is "+"; a lower-tail test is performed if the predicted sign is "–"; a two-tail test is performed if there is no predicted sign.
4. *Significant at the 0.05 level; **significant at the 0.01 level.
5. ER is not included in the models because of the concern of multicollinearity.
6. Based on the results of LM test and Hausman test, we would conclude that of the three alternative regression specifications, the ordinary least squares regression model is the better choice.

Table 8.10: Alternative regression specifications for combined ratio (CR) (Non-life)

Explanatory variable	Predicted sign	Ordinary least squares regression model	One-factor fixed-effects model	One-factor random-effects model
Intercept		548.73		1235.49
		(1.74)		(3.54)**
UI	+	5.30	52.67	23.79
		(0.47)	(2.66)**	(1.41)
IRC		−9.76	3.52	−2.77
		(−0.99)	(0.36)	(−0.25)
IRL	–	−12.62	−52.23	−28.60
		(−0.94)	(−2.41)**	(−2.19)*
ER				
LOGTA	–	−26.01	−196.78	−72.56
		(−1.56)	(−2.65)**	(−2.87)**
RCTA	+	3.68	5.72	0.38
		(1.70)*	(1.76)*	(0.12)
TNTPSF	+	0.73E−01	0.72E−01	0.74E−01
		(1.03)	(0.82)	(1.87) *
TAISF	+	−1.37	1.79	0.59
		(−1.18)	(0.48)	(0.48)
NANPW		0.23E−01	0.21E−01	0.22E−01
		(3.56)	(3.98)	(21.71)
ACNPW		−0.83E−03	0.11	0.67E−01
		(−0.01)	(0.72)	(0.49)
TLLA	+	0.79E−01	0.42	0.26
		(0.24)	(0.80)	(0.65)
CAM	+	12.47	19.91	15.38
		(1.38)	(1.99)*	(1.16)
Number of observations		1922	1922	1922
Adjusted R-Square		0.21	0.30	
F test		48.19	4.75	
		[0.00]	[0.00]	
LM test				19.37
				[0.00]
Hausman test				27.69
				[0.00]

Notes:

1. t statistics are in parenthesis.
2. p values are in brackets.
3. An upper-tail test is performed if the predicted sign is "+"; a lower-tail test is performed if the predicted sign is "–"; a two-tail test is performed if there is no predicted sign.
4. *Significant at the 0.05 level; **significant at the 0.01level.
5. Based on the results of LM test and Hausman test, we would conclude that of the three alternative regression specifications, the one-factor fixed-effects model is the better choice.

- Heteroskedasticity

Heteroskedasticity is the second econometric problems to be addressed in this study. It means that the disturbance variances of a linear model are not constant. The main consequence of heteroskedasticity is that the parameter estimates are not efficient. However, it should be noted that they remain linear, unbiased and consistent.

The panel data used in this research is wide, but short. That is, the observations come from many cross-sectional companies, but the time periods are relatively limited. The panel data of this kind is more oriented toward cross-sectional analysis (Greene, 2000) in which heteroskedasticity is a potential and common problem. Moreover, there is a large variation in the size of the values of explanatory variables in the panel data set used. In this case, heteroskedasticity tends to occur (Thomas, 1997).

In order to deal with heteroskedasticity, in this study standard errors which are robust to heteroskedasticity are calculated and the *t*-statistics of the coefficient estimates are computed using White's (1980) heteroskedasticity-consistent standard errors.

- Autocorrelation

Autocorrelation is the third econometric problem to be addressed in this study. It means that the observations of the error term are correlated. The main consequence of autocorrelation is that the standard errors of the coefficients tend to be underestimated. As a result the computed t-statistics tend to be overestimated. Nonetheless, the estimated coefficients remain unbiased (Studenmund, 1997).

Autocorrelation usually exists when the order of the observations has some particular meaning. Since there is no particular order across firms in the panel data set, it would be almost unlikely that autocorrelation would exist cross-sectionally. Besides, since the panel data set is short and the observations are not all consecutive in time because of the availability of data, it is not feasible to estimate the models with an autocorrelated error structure. This theory is confirmed by unsuccessful attempts to estimate the models using a robust covariance matrix for autocorrelation, and to correct for autocorrelation using Prais and Winsten algorithm provided by the LIMDEP package.

F-tests for the overall statistical goodness-of-fit of the empirical models are all significant at the 0.001 level. The adjusted R^2 values range from 0.04 to 0.52. The most appropriate models of the three alternative regression specifications for each of the four performance measures are chosen based on the results of LM test and Hausman test. For the *investment yield*, *return on shareholders' funds*, and *combined ratio* performance measures, their LM and Hausman test statistics are all greater than critical chi-squared values, suggesting that one-factor fixed-effects models are the most appropriate models for them. With respect to the *percentage change in shareholders' funds*, the LM test statistic is smaller than critical chi-squared value, indicating that an ordinary least squares regression model is better than a fixed-effects or random-effects model. The most appropriate models for these four performance measures are not necessarily the same because these performance measures capture different aspects of insurance performance. As pointed out in Table 8.1, *investment yield* focuses on the investment performance of an insurer and *combined ratio* focuses on underwriting performance. *Percentage change in shareholders' funds* measures the financial strength of an insurance firm, and *return on shareholders' funds* reflects profit made by an insurer as well as its financial strength.

To simplify the exposition, the discussion will be mainly focused on the consistent results for each variable. By consistent results, we mean the results holding for all alternative regression specifications in terms of sign and statistical significance. The results of three alternative regression specifications for the first three performance measures are largely consistent, whereas those for *combined ratio* are relatively less consistent.

For convenience, Table 8.11 summarises the results (sign and statistical significance) in Tables 8.4, 8.6, 8.9, and 8.10.

Table 8.11: Summary results (Non-life)

Explanatory variable	Predicted sign	IY			RSF			PCSF			CR		
		OS	FE	RE	OS	FE	RE	OS	FE	RE	OS	FE	RE
UI	–	–*	–*	–*	–	–	–*	–**	–**	–**	+	+**	+
IRC		–	–	–	+**	+**	+**	+	+	+	–	+	–
IRL	+	+**	+**	+**	+	+	+	+**	+**	+**	–	–**	–*
ER	+	+**	+**	+**	+	+	+						
LOGTA	+	+*	–	–	+**	+	+*	+	+	+	–	–**	–**
RCTA	–	–**	–**	–**	–	–	–	–	–**	–	+*	+*	+
TNTPSF	–	+	+	+				–	–*	–**	+	+	+*
TAISF	–	+	–	–				+	+	+	–	+	+
NANPW	+	+	+	–	+	+	+	+*	+**	+*	+	+	+
ACNPW		–	–	–	+	+	+**	+	+	+	–	+	+
TLLA	–	–**	–**	–**	–**	–**	–**	–**	–**	–**	+	+	+
CAM	–	+	+	+	–	–	–	+	+	+	+	+*	+

Note:

1. The listed predicted signs are for the performance measures IY, RSF, and PCSF. For the performance measure CR, the listed predicted signs should be reversed.
2. OS: ordinary least squares regression model; FE: one-factor fixed-effects model; RE: one-factor random-effects model.
3. *Significant at the 0.05 level; **significant at the 0.01 level.

1. Direction of the relationships between performance measures and explanatory variables

For each of the four performance measures, this subsection will only summarise the consistent results (in terms of sign and statistical significance) regarding the direction of the relationships between the performance measure and explanatory variables. A description of the measurement of the explanatory variables can be found in Section

8.3.2. The discussion of whether the empirical results are consistent with the hypotheses restated in Section 8.2, will be presented in the next subsection.

- *Investment yield*

The results for the *investment yield* models are shown in Tables 8.4 (a table with detailed results) and 8.11 (a table with summary results), based on ordinary least squares and one-factor fixed-effects and random-effects models methods. These models include all the explanatory variables. *Investment yield* is positively related to *interest rate level, equity returns, leverage, solvency margin, stability of underwriting operation, liquidity,* and negatively related to *unexpected inflation, interest rate changes, reinsurance dependence* and *stability of asset structure*. The estimated coefficients of *unexpected inflation, interest rate level, equity returns, reinsurance dependence and liquidity* are all statistically significant at the 0.05 level.

- *Return on shareholders' funds*

Both Tables 8.6 and 8.11 present the results for the *return on shareholders' funds* models. All the explanatory variables are included except for *leverage* and *affiliated investments*. In these models, the coefficients on *interest rate changes, interest rate level, equity returns, company size, solvency margin, liquidity,* and *stability of asset structure* are positive, whereas those on *unexpected inflation, reinsurance dependence* and *stability of underwriting operation* are negative. The coefficients of *interest rate changes* and *liquidity* are both statistically significant at a level of significance of 0.05.

- *Percentage change in shareholders' funds*

Tables 8.9 and 8.11 reports the results for the *percentage change in shareholders' funds* models. Except for *equity returns*, all the variables are included. This performance measure is positively related to *interest rate changes, interest rate level, company size,* *affiliated investments, solvency margin* and *liquidity,* and negatively related to *unexpected inflation, reinsurance dependence, leverage, stability of underwriting operation* and *stability of asset structure.* Four variables are significant in the models at the 0.05 level: *unexpected inflation, interest rate level, solvency margin, and liquidity.*

- *Combined ratio*

Combined ratio is positively related to *unexpected inflation, reinsurance dependence, leverage,* and *solvency margin,* and negatively related to *interest rate level, company size, liquidity,* and *stability of asset structure.* As stated in Chapter four, the *combined ratio* is a complete indicator of the underwriting performance of an insurer. The smaller the value for *combined ratio* the better the underwriting performance of the company. Thus, a positive relation between *combined ratio* and an explanatory variable means that the underwriting performance is negatively related to this variable.

There are no estimated coefficients of the explanatory variables which are all statistically significant at the 0.05 level across the three alternative regression specifications for *combine ratio* (Tables 8.10 or 8.11). However, it is noted that in one-factor fixed-effects and random-effects models the estimated coefficients of *interest rate level* and *company size* are statistically significant at the 0.05 level. Moreover, the estimated coefficients of *reinsurance dependence* are statistically significant at the 0.05 level in ordinary least squares regression and one-factor fixed-effects models.

2. Empirical results and hypotheses

In this subsection, whether the empirical results are consistent with the hypotheses will be investigated. The explanatory variables whose estimated coefficients are statistically significant in the models for more than one performance measure will be discussed first, followed by the remaining variables.

The overall results show that the estimated coefficients of *liquidity, unexpected inflation and interest rate level* are all statistically significant in the models for, at least, two out of these four performance measures. Consistent with the hypothesis that general insurers with more liquid assets outperform those with less liquid assets, the performance of non-life companies is positively related to asset liquidity.

This finding indicates that non-life insurer financial performance has been enhanced by increases in asset liquidity. This is possibly because non-life contracts are short term in nature. The policy period of most non-life contracts is one year or less. Moreover, in contrast to life insurance contracts, which are generally fixed in amount, non-life claims payments can vary widely depending on inflation, medical costs, construction costs, economic conditions, and changing value judgements by society. Therefore, the investment objective of *liquidity* is of particular importance to general insurers.

Nevertheless, it certainly does not mean that non-life firms should invest all of their funds in liquid assets because liquid assets in general produce relatively low returns in the long run. They should limit their liquid assets to a certain amount or percentage. Further investigation would be required if the amount or percentage were to be discovered.

This finding that there is a positive relationship between company performance and asset liquidity conflicts with that of Adam and Buckle (2000) who argue that high liquidity of assets could increase agency costs for owners because managers might take advantage of the benefits of liquid assets. That is, the evidence presented here does not provide support for the theory of agency costs.

As expected, non-life insurers' performance is negatively related to *unexpected inflation*, which supports the view that periods of higher *unexpected inflation* reduce financial performance for non-life companies. There are two possible reasons behind this. The first reason is on the asset side of the balance sheet. Since general insurers invest a high proportion of their funds in bonds, *unexpected inflation* makes real returns on fixed-rate bonds lower than expected. As a result, profit margins of non-life firms are compressed and financial performance is accordingly impaired.

The second reason is on the liability side of the balance sheet. In non-life business the insurer provides an indemnity to the policyholder against economic loss. Expected inflation would not have much effect on company performance because the actuary in general makes proper allowance for inflation. Nevertheless, if unexpected inflation occurs, it would be very likely that the actual claim costs would be greater than the expected claim costs. It is worth noting that Browne, Carson and Hoyt (2001) also found a significantly negative relation between *unexpected inflation* and performance for the US life insurers.

The evidence also indicates that *interest rate level* exerts a positive impact on general insurers' performance, which is consistent with the prediction that non-life companies are more likely to perform well when *interest rate level* is high. Moreover, *interest rate level* was found to be positively correlated (0.21) with *investment yield*. This is because bond investment earnings were important for the investment performance of non-life companies due to their significant proportion of the investment portfolios in bonds. As evidenced in Chapter two, the general insurance industry as a whole invested 24.4 per cent of its funds in bonds on average during the period 1986-1999 and the category of "bonds" was the dominant asset class. High interest rates bring high bond investment income, which accordingly enhances the investment performance of non-life firms. The evidence presented here is in line with that of Browne and Hoyt (1995) who found that US property-liability insurance companies are less likely to become insolvent during periods of high interest earnings.

The remainder of this section will discuss the explanatory variables whose estimated coefficients are only statistically significant in the models for one performance measure or statistically insignificant in the models for all performance measures.

The estimates of the *interest rate changes* coefficients in the models for the four performance measures are inconsistent. The *return on shareholder's funds* models produce some evidence that the performance of non-life companies is positively related to *interest rate changes*, whereas the remaining models do not. This might suggest that non-life companies tend to hold assets and liabilities with similar durations (Booth et al., 1999) or the former with a shorter duration than the latter (negative asset-liability duration mismatch). In general assets with short durations are liquid assets. The evidence presented here is in line with the finding presented previously that non-life company performance is significantly positively related to asset liquidity.

The reason why the combination of a negative asset-liability duration mismatch and rising interest rates results in increased profitability for the institution is as follows. Changes in interest rates have effects on the balance sheet of the insurer. If the durations of assets and liabilities are nearly matched, the interest rate risk is likely to be avoided to a great extent. However, if the duration of the former is shorter than that of the latter, an increase in interest rates leads to a larger decline in the value of liabilities than assets, and accordingly an increase in shareholders' funds.

It is interesting to note that for the *investment yield* models, the coefficients of *interest rate changes* are consistently negative but insignificant. This is possibly because unlike *return on shareholder's funds* and *percentage change in shareholders' funds*, the performance measure *investment yield* only measures asset returns and does not measure liability costs. Rising interest rates result in asset returns falling.

An implication of the results concerning *interest rate changes* is that, for a non-life company profits can be earned by assuming some degree of interest rate risk and managing it effectively. If interest rates are predicted to increase, the asset-liability duration mismatch should be negative. In this case, a net liability position resulting from a negative mismatch would be profitable. Conversely, if interest rates are predicted to decrease, the asset-liability duration mismatch should be positive. The value of the company grows as interest rates fall.

For the reasons indicated above, the variable *equity returns* is only included in the models for *investment yield* and *return on shareholders' funds*. The estimates of the *equity returns* coefficients in the models for *investment yield* are positive and statistically significant at the 0.01 level. This provides some support for the view that high returns on equities enhance the investment performance of non-life insurance firms. The results that the rates of return on equities play a part in the non-life company performance are hardly surprising because the non-life industry as a whole invested 12.5 per cent of their funds in equities on average during the period 1986-1999. Also, there was a very bullish trend in the equity markets over the sample period. Nonetheless, the coefficients on this variable in the models for *return on shareholders' funds* are statistically insignificant, though positive. One possible explanation is that unlike *investment yield*, *return on shareholders' funds* is an overall performance measure which reflects the financial strength of an insurer as well as the profit it earns. Consequently, the effects of *equity returns* on *return on shareholders' funds* are less than those on *investment yield*.

Consistent with the hypothesis, *company size* is found to be significantly positively related to performance in some of the models for *return on shareholders' funds* and *combined ratio*. This evidence is consistent with that of Browne, Carson and Hoyt (2001) who found that *company size* is positively related to financial performance for US life insurers. However, this finding might conflict with Birkmaier and Helfenstein's (2000) view that there is no clear evidence that large non-life insurers have significant cost advantage over small or medium-sized companies.

The evidence discovered in this research might provide some support for the argument that larger non-life companies tend to exhibit superior performance to smaller companies. There could be a number of possible reasons behind this. The first is that economies of scale make larger companies more cost-saving than smaller companies. Although non-life insurance firms, like other financial institutions, provide services not goods, they can gain economies of scale by increasing their scale of operations. For instance, many small general insurers do not employ any actuaries. Managerial economies can be achieved in the administration of a large non-life firm by splitting up management jobs and employing qualified actuaries. Second, since non-life business is volatile by nature, it is important for non-life companies to employ risk management techniques. Larger companies tend to employ a wider range of risk management techniques than smaller companies. For example, large non-life insurers may be better able to engage in corporate risk management by modifying their operating and financing strategies. Third, larger non-life companies normally have relatively great capacity for dealing with adverse market fluctuations than smaller firms. The fourth possible reason is based mainly around arguments invoking agency cost. It is more likely for small companies to face severe agency problems than large companies. Agency cost incurred would reduce company profitability.

The coefficient estimates of *reinsurance dependence* are found to be negatively related to performance across all models. Moreover, they are significant in half of the models. In particular its estimated coefficients in the *investment yield* models are all statistically significant at the 0.01 level. Because of their limited capacity and the volatile nature of their business, most general insurers rely heavily on reinsurance in order to avoid catastrophic losses and reduce the net drain on surplus by passing on a portion of any risk too large to handle. However, it should be noted that there is a cost for reinsurance.

The finding of this research lends support to the notion that general insurers with low retention limit act as if they were the brokers of reinsurers because a high proportion of their premiums have to be handed over to reinsurance companies and to a great extent their performance would depend on that of their reinsurers. Nevertheless, this evidence does not indicate that non-life companies should not take out reinsurance cover at all. An implication of the results is that the benefits of reinsurance become smaller beyond a threshold. Further research would be required if the optimal threshold were to be found. Non-life insurers have to determine an appropriate retention level depending on their individual situations and they have to try to strike a balance between decreasing insolvency risk and reducing potential profitability.

The coefficients of the *leverage* variable are significantly negatively related to performance in some of the models for *percentage change in shareholders' funds* and *combined ratio*, providing some support to the hypothesis that insurers with higher leverage have a higher probability of insolvency. The inverse relation between performance and *leverage* is consistent with that reported in the US life insurance industry by Colquitt and Hoyt (1997), and Browne, Carson and Hoyt (2001). An implication of the results is that if "capital-poor" general insurers in the UK have a high degree of leverage, then this may call for tighter external solvency monitoring of these companies. However, the evidence presented here conflicts with Adams and Buckle's (2000) finding of a positive relation between *leverage* and operational performance in the Bermuda insurance market. One possible explanation of this contradiction is that Bermuda has favourable corporate taxation regulations which promote the rapid accumulation of reserves. In the Bermuda market, the degree of financial leverage might reflect insurers' ability to manage their risk exposure to unexpected losses. Those with high leverage usually also have better ability to facilitate enterprise risk management and accordingly have better operational performance.

No evidence is found for the *affiliated investments* hypothesis that predicts an inverse relationship between *affiliated investment* and performance. The signs of the estimated coefficients are inconsistent across the models. This means that the variable *affiliated investments* does not have a significant influence on the performance of non-life insurers in the sample of this study.

Consistent with the hypothesis, *solvency margin* is positively related to *investment yield*, *percentage change in shareholders' funds*, and *return on shareholders' funds,* and some of its estimated coefficients are statistically significant at the 0.05 level. This result provides considerable support to the hypothesis that non-life firms with higher *solvency margin* outperform those with lower *solvency margin*. This is probably because financially sound companies are better able to attract prospective policyholders and recruit able employees. It is also noted that *solvency margin* is negatively related to performance in the models for *combined ratio*. This may be because non-life companies with high solvency margin are more capable of underwriting riskier business. As a consequence, these companies in general have high combined ratios.

With respect to *stability of underwriting operation* and *stability of asset structure*, all the estimated coefficients are insignificant and inconsistent across all four measures of financial performance.

To sum up, the empirical results holding for all alternative regression specifications for all four performance measures in terms of sign reveal that the performance of the non-life insurance industry is positively related to *interest rate level*, *equity returns*, and *liquidity*, and negatively related to *unexpected inflation* and *reinsurance dependence*. Moreover, the results also show that the estimated coefficients of *liquidity*, *unexpected inflation* and *interest rate level* are all statistically significant at the 0.05 level in the models for, at least, two out of four performance measures. Thus, among the factors in question these three above-mentioned factors can be regarded as statistically significant determinants of UK general insurers' performance.

8.6 Empirical Analysis of the Life Insurance Industry

8.6.1 The Data

The life empirical analysis is based on cross-sectional and time-series data (1986-1999) obtained from SynThesys Life (Version 3.32) and Datastream. The number of life offices in SynThesys Life is 311. The way of dealing with life data is the same as that of dealing with non-life data. In the final panel data set, there are 1,996 insurer-year observations for 230 life offices over 14 years.

Tables 8.12 and 8.13 present descriptive statistics and correlation matrix for the sample firms respectively. The correlation coefficients between the firm-specific variables are small, but those between the economic variables are relatively high.

Table 8.12: Descriptive statistics of dependent and explanatory variables (Life)

Variable	Mean	Standard deviation	Minimum	Maximum	Median	Skewness	Kurtosis
IY	5.57	1.88	1.00	10.59	5.36	0.41	–0.19
PCSF	21.52	70.02	–350.62	697.43	6.71	3.69	22.06
RSF	19.37	92.32	–556.33	583.57	10.86	0.49	11.55
UI	–4.92	1.37	–7.56	–3.34	–4.57	–0.65	–0.99
IRC	–0.42	1.85	–4.61	2	0.16	–0.68	–0.37
IRL	8.56	1.79	5.08	11.8	9.06	–0.34	–0.52
ER	6884.00	3749.41	2406.92	14904.31	4967.84	0.78	–0.61
LOGTA	12.42	2.40	2.40	18.22	12.78	–0.63	0.40
RCTA	6.32	101.72	–3092.92	2537.30	0.31	–3.75	660.44
AHCLLTA	51.63	40.28	0	100.00	58.87	–0.15	–1.69
TRSF	19730.66	86091.39	–981735	1667318	3302.46	8.29	131.73
FAR	9.51	71.24	–2960.47	339.17	2.95	–36.05	1517.11
ACNPE	207.95	5516.90	–29876	232900	6.01	38.43	1597.47
TLMLA	52717.34	1342762	–3869400	58266650	305.95	41.12	1774.40
CAM	1.45	2.16	0	19.24	0.79	3.87	19.91
LGARTR	54.38	37.62	0	100	58.47	–0.24	–1.40
PRTR	39.93	38.29	–1.77	100	31.46	0.44	–1.32
PHRTR	3.85	15.44	0	100	0	4.87	24.05
ORTR	0.11	1.38	0	39.55	0	19.44	443.68
UARTR	1.33	7.89	0	100	0	9.91	111.39

Table 8.13: Correlation matrix for dependent and explanatory variables (Life)

Variable	IY	PCSF	RSF	UI	IRC	IRL	ER	LOGTA
IY	1.00	–0.05	–0.02	–0.13	–0.03	0.42	–0.39	–0.32
PCSF	–0.05	1.00	0.11	0.03	0.00	–0.04	0.03	0.06
RSF	–0.02	0.11	1.00	0.05	–0.02	–0.01	0.00	0.25
UI	–0.13	0.03	0.05	1.00	–0.23	–0.39	0.54	0.14
IRC	–0.03	0.00	–0.02	–0.23	1.00	0.13	–0.06	–0.02
IRL	0.42	–0.04	–0.01	–0.39	0.13	1.00	–0.91	–0.19
ER	–0.39	0.03	0.00	0.54	–0.06	–0.91	1.00	0.21
LOGTA	–0.32	0.06	0.25	0.14	–0.02	–0.19	0.21	1.00

	IY	PCSF	RSF	UI	IRC	IRL	ER	LOGTA
RCTA	–0.01	0.02	0.02	0.00	0.02	–0.02	0.03	–0.04
AHCLLTA	–0.55	0.03	–0.07	–0.03	0.01	0.03	–0.02	0.19
TRSF	–0.08	–0.04	0.03	0.03	–0.02	–0.06	0.06	0.15
FAR	0.05	0.03	0.00	0.01	–0.01	–0.01	0.02	–0.03
ACNPE	0.02	–0.01	–0.01	–0.02	0.03	0.01	–0.02	–0.06
TLMLA	–0.05	–0.02	0.00	0.02	0.02	–0.03	0.03	0.01
CAM	0.15	0.01	–0.09	0.01	–0.03	–0.01	0.02	–0.31
LGARTR	0.12	–0.03	0.04	–0.12	0.04	0.13	–0.15	–0.17

	RCTA	AHCLLTA	TRSF	FAR	ACNPE	TLMLA	CAM	LGARTR
RCTA	1.00	–0.05	–0.01	0.03	0.00	0.00	0.10	0.04
AHCLLTA	–0.05	1.00	0.05	–0.11	–0.02	0.05	–0.33	–0.18
TRSF	–0.01	0.05	1.00	–0.01	–0.01	0.05	–0.08	–0.11
FAR	0.03	–0.11	–0.01	1.00	0.01	–0.01	0.08	0.01
ACNPE	0.00	–0.02	–0.01	0.01	1.00	0.00	0.14	0.00
TLMLA	0.00	0.05	0.05	–0.01	0.00	1.00	–0.03	0.02
CAM	0.10	–0.33	–0.08	0.08	0.14	–0.03	1.00	0.14
LGARTR	0.04	–0.18	–0.11	0.01	0.00	0.02	0.14	1.00

	IY	PCSF	RSF	UI	IRC	IRL	ER	LOGTA
PRTR	–0.23	0.02	–0.01	0.08	–0.04	–0.09	0.10	0.28
PHRTR	0.19	0.04	–0.03	0.05	0.01	–0.08	0.09	–0.15
ORTR	0.05	–0.02	–0.03	0.00	0.01	–0.03	0.04	–0.11
UARTR	0.07	–0.02	–0.05	0.06	–0.01	–0.03	0.02	–0.23

	RCTA	AHCLLTA	TRSF	FAR	ACNPE	TLMLA	CAM	LGARTR
PRTR	–0.01	0.32	0.14	–0.03	–0.01	–0.02	–0.21	–0.88
PHRTR	0.02	–0.26	–0.05	0.02	0.05	–0.01	0.14	–0.17
ORTR	0.00	–0.08	–0.02	0.03	0.00	0.00	0.03	–0.07
UARTR	–0.17	–0.14	–0.03	0.06	0.00	–0.01	0.06	–0.07

	PRTR	PHRTR	ORTR	UARTR
PRTR	1.00	–0.23	–0.04	–0.13
PHRTR	–0.23	1.00	0.17	–0.01
ORTR	–0.04	0.17	1.00	–0.01
UARTR	–0.13	–0.01	–0.01	1.00

8.6.2 Empirical Results

The empirical analysis of determinants of performance is conducted based on 1,996 company-year data from 1986 through 1999 for 230 UK life insurance companies. The way of conducting the empirical analysis for life insurance companies is the same as that for non-life insurance companies. Likewise, ordinary least squares regression model, one-factor fixed-effects model and one-factor random-effects model are used to estimate each of the three performance measures, *investment yield*, *percentage change in shareholders' funds* and *return on shareholders' funds*. Tables 8.14, 8.15 and 8.16 show the empirical results.

Table 8.14: Alternative regression specifications for investment yield (IY) (Life)

Explanatory variable	Predicted sign	Ordinary least squares regression model	One-factor fixed-effects model	One-factor random-effects model
Intercept		7.18 (9.99)**		6.19 (5.57)**
UI	–	0.46E–01 (1.67)	0.25E–01 (1.23)	0.31 (1.50)
IRC	–	–0.77E–01 (–4.79)**	–0.83E–01 (–7.39)**	–0.83E–01 (–6.78)**
IRL		0.44 (10.75)**	0.49 (17.07)**	0.48 (15.38)**
ER		–0.79E–05 (–0.38)	0.32E–05 (0.21)	0.19E–05 (0.12)
LOGTA	+	–0.13 (–8.53)	0.18E–01 (0.33)	–0.70E–01 (–2.91)
RCTA	–	–0.57E–03 (–1.70)*	–0.99E–03 (–3.75)**	–0.71E–03 (–2.62)**
AHCLLTA		–0.25E–01 (–31.60)**	–0.40E–01 (–12.98)**	–0.31E–01 (–22.57)**
TRSF	–	–0.18E–06 (–0.75)	–0.43E–06 (–2.04)*	–0.34E–06 (–0.99)
FAR	+	0.21E–04 (0.07)	0.12E–02 (6.31)**	0.85E–03 (2.32)*
ACNPE		0.17E–06 (0.03)	0.11E–05 (0.26)	0.33E–06 (0.08)
TLMLA	–	–0.16E–07 (–2.41)**	0.11E–07 (–2.55)	0.90E–08 (0.53)
CAM	–	–0.73E–01 (–2.74)**	–0.13 (–5.56)**	–0.11 (–9.18)**
LGARTR		–0.22E–01 (–4.82)**	17.17 (3.92)**	–0.20E–01 (–1.96)*
PRTR		–0.21E–01 (–4.48)**	17.16 (3.92)**	–0.20E–01 (–1.97)*
PHRTR		–0.13E–01 (–2.50)**	17.16 (3.92)**	–0.18E–01 (–1.73)
ORTR		–0.29E–01 (–1.66)	17.20 (3.93)**	–0.99E–03 (0.04)
UARTR		–0.28E–01 (–5.16)**	17.17 (3.92)**	–0.21E–01 (–1.94)
Number of observations		1996	1996	1996
Adjusted R-Square		0.53	0.75	
F test		133.07 [0.00]	25.59 [0.00]	

LM test	1547.96
	[0.00]
Hausman test	70.41
	[0.00]

Notes:

1. t statistics are in parenthesis.
2. p values are in brackets.
3. An upper-tail test is performed if the predicted sign is "+"; a lower-tail test is performed if the predicted sign is "–"; a two-tail test is performed if there is no predicted sign.
4. *Significant at the 0.05 level; **significant at the 0.01 level.
5. Based on the results of LM test and Hausman test, we would conclude that of the three alternative regression specifications, the one-factor fixed-effects model is the better choice.

Table 8.15: Alternative regression specifications for percentage change in shareholders' funds (PCSF) (Life)

Explanatory variable	Predicted sign	Ordinary least squares regression model	One-factor fixed-effects model	One-factor random-effects model
Intercept		35.07 (1.00)		26.38 (0.47)
UI	–	1.36 (0.84)	2.04 (1.20)	1.57 (1.05)
IRC	–	0.57 (0.61)	0.85 (0.99)	0.60 (0.67)
IRL		–4.03 (–1.74)	–4.48 (–1.94)	–4.09 (–1.79)
ER		–0.17E–02 (–1.35)	–0.29E–02 (–2.37)*	–0.22E–02 (–1.81)
LOGTA	+	2.19 (3.08)**	5.81 (2.19)*	3.43 (2.66)**
RCTA	–	0.12E–01 (1.10)	0.36E–01 (2.93)	0.18E–01 (1.00)
AHCLLTA		0.79E–01 (2.01)*	0.66E–02 (0.05)	0.72E–01 (0.95)
TRSF	–	–0.40E–04 (–1.97)*	–0.78E–04 (–2.32)**	–0.49E–04 (–2.14)*
FAR	+	0.33E–01 (6.23)**	0.45E–01 (3.00)**	0.40E–01 (1.65)*
ACNPE		0.18E–03 (–2.86)**	–0.47E–04 (–0.80)	–0.95E–04 (–0.32)
TLMLA	–	–0.11E–05 (–8.85)**	–0.78E–06 (–5.38)**	0.89E–06 (–0.73)
CAM	–	1.18 (1.17)	1.40 (1.28)	1.23 (1.40)
LGARTR		0.58E–01 (0.55)	–380.84 (–1.59)	0.56E–01 (0.12)
PRTR		0.72E–01 (0.67)	–380.94 (–1.59)	0.58E–01 (0.13)
PHRTR		0.34 (2.03)*	–380.62 (–1.59)	0.37 (0.76)
ORTR		–1.07 (–1.76)	–379.45 (–1.59)	–0.32 (–0.22)
UARTR		0.24E–01 (0.15)	–380.58 (–1.59)	0.10 (0.19)
Number of observations		1996	1996	1996
Adjusted R-Square		0.01	0.03	
F test		1.85 [0.02]	1.28 [0.00]	

LM test	7.78
	[0.01]
Hausman test	23.14
	[0.15]

Notes:

1. t statistics are in parenthesis.
2. p values are in brackets.
3. An upper-tail test is performed if the predicted sign is "+"; a lower-tail test is performed if the predicted sign is "–"; a two-tail test is performed if there is no predicted sign.
4. *Significant at the 0.05 level; **significant at the 0.01 level.
5. Based on the results of LM test and Hausman test, we would conclude that of the three alternative regression specifications, the one-factor random-effects model is the better choice.

Table 8.16: Alternative regression specifications for return on shareholders' funds (RSF) (Life)

Explanatory variable	Predicted sign	Ordinary least squares regression model	One-factor fixed-effects model	One-factor random-effects model
Intercept		–3.71		1.05
		(–0.09)		(0.02)
UI	–	4.52	5.45	5.02
		(2.26)	(3.20)	(3.18)
IRC	–	0.17	0.22	0.16
		(0.14)	(0.24)	(0.17)
IRL		–5.13	–4.29	–4.37
		(–1.77)	(–1.83)	(–1.81)
ER		–0.43E–02	–0.51E–02	–0.46E–02
		(–2.79)**	(–3.70)**	(–3.61)**
LOGTA	+	10.75	10.38	9.90
		(11.82)**	(3.56)**	(6.44)**
RCTA	–	0.35E–01	0.71E–01	0.46E–01
		(2.16)	(8.48)	(2.36)
AHCLLTA		–0.30	0.83E–01	–0.18
		(–5.28)**	(0.55)	(–1.96)
TRSF				
FAR	+	–0.37E–02	–0.38E–02	–0.89E–02
		(–0.20)	(–0.36)	(–0.34)
ACNPE		0.17E–03	–0.55E–05	0.47E–04
		(1.75)	(–0.07)	(0.15)
TLMLA	–	–0.28E–06	–0.13E–05	–0.11E–05
		(–1.84)*	(–2.62)**	(–0.82)
CAM	–	–2.48	–1.41	–1.86
		(–2.10)*	(–1.34)	(–1.98)*
LGARTR		0.11	35.89	0.32E–01
		(0.96)	(0.27)	(0.06)
PRTR		–0.46E–01	35.79	–1.00E–01
		(–0.37)	(0.27)	(–0.17)
PHRTR		–0.27E–01	36.11	–0.19
		(–0.18)	(0.28)	(–0.03)
ORTR		–0.34E–01	42.30	2.02
		(–0.03)	(0.32)	(1.22)
UARTR		0.50E–01	36.45	0.25
		(0.33)	(0.28)	(0.39)
Number of observations		1996	1996	1996
Adjusted R-Square		0.08	0.39	
F test		12.39	6.22	
		[0.00]	[0.00]	
LM test				918.65
				[0.00]

Hausman test	28.90 [0.02]

Notes:
1. t statistics are in parenthesis.
2. p values are in brackets.
3. An upper-tail test is performed if the predicted sign is "+"; a lower-tail test is performed if the predicted sign is "–"; a two-tail test is performed if there is no predicted sign.
4. *Significant at the 0.05 level; **significant at the 0.01 level.
5. Based on the results of LM test and Hausman test, we would conclude that of the three alternative regression specifications, the one-factor fixed-effects model is the better choice.

In order to avoid false significance not all explanatory variables are included in the models for all three performance measures. For instance, since the explanatory variable *leverage* has the same denominator as the dependent variable *return on shareholders' funds*, it is excluded from the models for this dependent variable.

The above-mentioned three econometric problems, multicollinearity, heteroskedasticity and autocorrelation, are addressed as follows:

1. Multicollinearity

It is possible that some degree of collinearity exists between the explanatory variables in the models. As in the non-life analysis, the first step is to examine the simple correlation coefficient for each pair of explanatory variables. Table 8.13 shows that there is fairly high degree of correlation between *interest rate level* and *equity returns*, and between *life & general annuity reserve to total reserve* and *pension reserve to total reserve*. As previously mentioned, high simple correlation coefficients indicate a high probability of multicollinearity. To give a formal indication of the severity of multicollinearity, the values of VIF for each of the explanatory variables are calculated and presented in Table 8.17. This table shows that the above-mentioned explanatory variables have high VIF values, especially the last two.

Table 8.17: Variance inflation factor for explanatory variables (Life)

Explanatory variable	Variance inflation factor
UI	1.69
IRC	1.15
IRL	6.90
ER	8.28
LOGTA	1.33
RCTA	1.05
AHCLLTA	1.29
TRSF	1.04
FAR	1.02
ACNPE	1.03
TLMLA	1.01
CAM	1.26
LGARTR	35.89
PRTR	37.74
PHRTR	6.95
ORTR	1.09
UARTR	2.61

Similarly, three remedies for multicollinearity are considered one by one. These remedies are obtaining more data, dropping multicollinear variables, and doing nothing. Obtaining more data is also considered infeasible because of the availability of the data.

In the case of the life analysis, we do not consider dropping any of the multicollinear variables. There are two reasons for this. First, as mentioned earlier dropping variables from the equations could lead to specification bias. Second, all the multicollinear variables are theoretically important. For instance, the life insurance industry as a whole had invested 33.3 per cent and 21.2 per cent of its funds in equities and bonds during the period 1986-1999. Therefore, both *equities returns* and *interest rate level* are considered important to company performance and need to be kept in the equations. In addition, product mix is also considered important. As a result, *life & general annuity reserve to total reserve* and *pension reserve to total reserve* are not excluded from the equations. This way of dealing with multicollinearity is in line with the views of econometricians such as Studenmund (1997) that it is often best to leave an equation unadjusted in the face of all but extreme multicollinearity. In fact, compared to the alternatives of possible omitted variable bias or accidentally significant regression results, the somewhat low t-scores seem like a minor problem.

2. Heteroskedasticity

Since this panel data is also wide and short, the phenomenon of heteroskedasticity is, inevitably, present. The way of dealing with heteroskedasticity in this case is the same as that in the case of the non-life analysis. White's (1980) heteroskedasticity corrected covariance matrix is used and heteroskedasticity-consistent standard errors are computed.

3. Autocorrelation

As previously stated, autocorrelation usually exists when the order of the observations has some particular meaning. Similarly, there is no particular order across companies in this panel data set and therefore cross-sectional autocorrelation is considered relatively unlikely to be present. As to time-series autocorrelation, it is difficult to estimate the models with an autocorrelated error structure and autocorrelation correction for the same reasons indicated in the non-life analysis. As a result, the models estimated here do not include any autocorrelated structure.

Tables 8.14, 8.15, 8.16 report the F-test results for the overall statistical goodness-of-fit of the empirical models; all models are statistically significant at the 0.001 level except for the ordinary least squares regression model for *percentage change in shareholders' funds* (p-value = 0.02). There is a considerable diversity in the range of the adjusted R^2 values (0.01 to 0.75). Based on the results of LM test and Hausman test, the most appropriate models for *investment yield* and *return on shareholders' funds* are one-factor fixed-effects models, while the most appropriate model for *percentage change in shareholders' funds* is a one-factor random-effects model.

Similarly, only the consistent results in terms of sign and statistical significance for each variable are discussed. The results of three alternative regression specifications for *investment yield* are largely consistent and so are those for *return on shareholders' funds* and *percentage change in shareholders' funds*. It is also noted that the results are largely consistent between the last two performance measures *percentage change in shareholder's funds* and *return on shareholders' funds*, but are somewhat less consistent with the results for the performance measure *investment yield*.

For convenience, Table 8.18 summarises the results (sign and statistical significance) in Tables 8.14, 8.15, and 8.16.

Table 8.18: Summary results (Life)

Explanatory Variable	Predicted Sign	IY			PCSF			RSF		
		OS	FE	RE	OS	FE	RE	OS	FE	RE
UI	–	+	+	+	+	+	+	+	+	+
IRC	–	–**	–**	–**	+	+	+	+	+	+
IRL		+**	+**	+**	–	–	–	–	–	–
ER		–	+	+	–	–*	–	–**	–**	–**
LOGTA	+	–	+	–	+**	+*	+**	+**	+**	+**
RCTA	–	–*	–**	–**	+	+	+	+	+	+
AHCLLTA		–**	–**	–**	+*	+	+	–**	+	–
TRSF	–	–	–*	–	–*	–**	–*			
FAR	+	+	+**	+*	+**	+**	+*	–	–	–
ACNPE		+	+	+	+**	–	–	+	–	+
TLMLA	–	–**	+	+	–**	–**	+	–*	–**	–
CAM	–	–**	–**	–**	+	+	+	–*	–	–*
LGARTR		–**	+**	–*	+	–	+	+	+	+
PRTR		–**	+**	–*	+	–	+	–	+	–
PHRTR		–**	+**	–	+*	–	+	–	+	–
ORTR		–	+**	–	–	–	–	–	+	+
UARTR		–**	+**	–	+	–	+	+	+	+

Note:

1. OS: ordinary least squares regression model; FE: one-factor fixed-effects model; RE: one-factor random-effects model.
2. *Significant at the 0.05 level; **significant at the 0.01 level.

1. Direction of the relationships between performance measures and explanatory variables

Similarly, this subsection only summarises the consistent results regarding the direction of the relationships between the performance measure and explanatory variables. The relevant discussions can be found in the next subsection.

- *Investment yield*

Table 8.14 (a table with detailed results) and Table 8.18 (a table with summary results) present the results for the *Investment yield* ordinary least squares, one-factor fixed-effects and random-effects models. In these models, the coefficients on *unexpected inflation, interest rate level, free asset ratio and stability of asset structure* are positive, whereas those on *interest rate changes, reinsurance dependence, assets held to cover linked liabilities, leverage and stability of underwriting operation* are negative. The estimated coefficients of *interest rate changes, interest rate level, reinsurance dependence, assets held to cover linked liabilities and stability of asset structure* are all statistically significant at the 0.01 level.

- *Percentage change in shareholders' funds*

Percentage change in shareholders' funds is positively related to *unexpected inflation, interest rate changes, company size, reinsurance dependence, assets held to cover linked liabilities* and *free asset ratio,* and negatively related to *interest rate level, equity returns, leverage, stability of asset structure* and *other reserve to total reserve*. Three variables are significant in the models at the 0.05 level: *company size, leverage*, and *free asset ratio* (Tables 8.15 or 8.18).

- *Return on shareholders' funds*

Tables 8.16 and 8.18 report the empirical results for the *return on shareholders' funds* models. This performance measure is positively related to *unexpected inflation, interest rate changes, company size, reinsurance dependence, liquidity, stability of asset structure, life & general annuity reserve to total reserve* and *unspecified additional reserve to total reserve*, and negatively related to *interest rate level, equity returns,* and *free asset ratio*. The coefficients on *equity returns* and *company size* are statistically significant at the 0.01 level (Tables 8.16 or 8.18).

2. Empirical results and hypotheses

The only explanatory variable whose estimated coefficients are statistically significant in the models for more than one performance measure is *company size*. As a result, this variable will be discussed first, followed by the remaining variables.

The estimates of the *company size* coefficients of the models for *percentage change in shareholders' funds* and *return on shareholders' funds* are positive and statistically significant at the 0.05 level, which supports the view that life insurance companies with more assets outperform those with less assets. That is, the size of the company is positively related to its performance. This evidence is consistent with that of Browne, Carson and Hoyt (2001) who find that larger life insurance companies produce superior financial performance. The possible reasons why *company size* is positively related to company performance have been discussed in the previous section, including economies of scale, the capability of use of risk management techniques, the capacity for dealing with adverse market fluctuations, and the agency cost problem.

The estimates of the *equity returns* coefficients in the models for *percentage change in shareholders' funds* and *return on shareholders' funds* are all negative and most of them are significant at the 0.01 level. This evidence provides some support for the view of Booth et al. (1999) that investing a high proportion of the portfolio in equities could increase insolvency risk and is consistent with Browne, Carson and Hoyt's (1999; 2001) findings of a negative relationship between *equity returns* and financial performance. This result lends support to the view that policyholders may surrender their policies or take policy loans when alternative investment returns in financial markets are attractive (Outreville, 1990; Carson and Hoyt, 1992). It is interesting to note that no significant relation between *equity returns* and *investment yield* was found. This finding is surprising given the life insurance industry's heavy investments in equities over the sample period. This is possibly because *equity returns* is strongly related to *interest rate level*. In multiple-regression analyses, it is common that an independent variable (e.g. *equity returns*) will seem to have an important effect on a dependent variable (e.g. *investment yield*) when considered by itself but will not be significant after adjusting for another independent variable (*interest rate level*). It is worth emphasising that although *equity returns* was not found consistently significant across all the models, we should not necessarily exclude this variable from DST applications.

As expected, the *interest rate changes* variable in the model for *investment yield* has a statistically significant negative sign at the 0.01 level, indicating that the greater the changes in interest rates, the worse the life office performance, *ceteris paribus*. This negative relationship may be due to the positive asset-liability mismatch of life offices. This evidence is in line with that of Browne, Carson and Hoyt (1999) who find supportive evidence that US life-health insurance companies are more likely to become insolvent during periods of increases in long-term interest rates. However, the coefficients on *interest rate changes* in the models for *percentage change in shareholders' funds* and *return on shareholders' funds* are both insignificant, though positive. The above inconsistent results suggest that *interest rate changes* may not be an important performance determinant of life offices. This is in line with Browne, Carson and Hoyt's (2001) finding of a negative but insignificant relation between *interest rate changes* and all three performance measures used, including percentage change in surplus, return on assets and return on equities.

The coefficients of the *interest rate level* variable in the model for *investment yield* are positive and statistically significant at the 0.01 level, whereas those in the models for *percentage change in shareholders' funds* and *return on shareholders' funds* are insignificant, though negative. Nonetheless, as evidenced previously, the non-life results indicate that *interest rate level* has a positive and, in most cases, significant effect on general insurers' performance. How can these inconsistent results be reconciled? Unlike general insurers, life offices invest a relatively small proportion of their funds in bonds. As a result, the impact of *interest rate level* on company performance is less significant in life insurance than in general insurance. Moreover, life policyholders may be interest rate sensitive. When interest rates go up, policyholders will take the advantage of their policies' options such as policy surrenders and policy loans, and invest the cash surrender value or loan principal in higher yielding securities. Since bond returns largely depend on the level of interest rates, when interest rates go up, company performance will be adversely affected if the gain from bond returns cannot compensate for the loss from disintermediation. In this case, the relationship between performance and *interest rate level* would be negative. If the gain from bond returns can compensate for the disintermediation loss when interest rates go up, the reverse is true.

The estimates of the *reinsurance dependence* coefficients in the model for *investment yield* are negative and statistically significant at the 0.01 level, which supports the view that life offices with high retention level outperform those with low retention level. This finding is the same as that obtained from the non-life analysis in the previous section. This may be because there is a cost for reinsurance. The ceding company has to pay a proportional share of the premium collected to the reinsurer. The larger the amount of the premium the less funds the company can invest in assets. However, the estimated coefficients in the models for *percentage change in shareholders' funds* and *return on shareholders' funds* are positive, though insignificant. This finding is in line with Browne, Carson and Hoyt's (2001) finding of a positive but insignificant relation between *reinsurance dependence* and performance.

As previously stated, the variable *leverage* is not included in the models for *return on shareholders' funds* in order to avoid false significance. In the models for *investment yield* and *percentage change in shareholders' funds*, the estimates of the *leverage* coefficients are all negative and most of them statistically significant at the 0.05 level. This evidence provides considerable support for the view that life insurers with low *leverage* have better performance than those with high leverage, and is consistent with the findings of Carson and Hoyt (1995) and Browne, Carson and Hoyt (2001). This finding appears to suggest that high-leveraged life offices expose themselves to insolvency risk to a large extent. An implication for life offices is that the ratio of the total reserve to shareholders' funds should be kept within a certain limit in order to reduce insolvency risk. Also, there is an implication for insurance regulators. The life insurers with high leverage may need more in-depth scrutiny by regulators.

The coefficients of the *free asset ratio* variable in the models for *investment yield* and *percentage change in shareholders' funds* are positive and statistically significant at the 0.05 level except one regression specification. The results are generally consistent with the results for general insurers reported in the non-life section. As stated previously, general insurers with higher *solvency margin* are better able attract prospective policyholders, and accordingly outperform those with lower *solvency margin*. In the case of life insurance, life offices with low *free asset ratio* are in general forced to cut bonus payouts to policyholders. Consequently, these offices are unable to attract prospective policyholders and some of their existing policyholders may surrender their policies. Therefore, their financial performance may be impaired. It is worth noting that many financial rating agencies such as A.M Best Company, Moody's Investors Service and Standard and Poor's evaluate insurers' *solvency margin* or *free asset ratio* to provide solvency ratings of insurance companies. In general, individual insurance buyers purchase insurance without giving too much thought to the insurer's probability of insolvency. This may be because insurance solvency regulation helps to ensure that most insurers hold sufficient capital so that some of these buyers do not pay much attention to these solvency ratings. On the other hand, the insurer solvency ratings are used extensively by business policyholders. If an insurer were downgraded or placed under review for a possible downgrade by agencies, its shares could plummet because of the potential of the downgrade to disrupt sales. The reason for a reduction in sales is that the downgrade would discourage financial advisers, a very important distribution channel in the UK, from recommending the insurer's products. For instance, due to its weakened financial position AMP, an UK financial services giant, was downgraded by Standard & Poor's in July 2000. Its shares plummeted immediately after the announcement from the agency and sales were also adversely affected.

The estimates of the *liquidity* coefficients are not consistent across all three measures of financial performance. These results seem to contradict those reported in US-based studies such as Browne, Carson and Hoyt (2001) who find that life offices with more liquid assets outperform those with less liquid assets. One possible explanation for the absence of the variable as a determinant in the UK life models is that this variable fluctuated to a lesser extent during the sample period 1986-1999 than it did in the above-mentioned US study covering the period 1985-1995.

As evidenced in the previous section, there is a significantly positive relation between *liquidity* and UK general insurer performance. One possible explanation for *liquidity* as one of the UK general insurer performance determinants is that general insurers are more likely to face liquidity problems and need liquidity to meet unexpected claims costs, especially those writing catastrophe prone lines of business. The claims amounts and timing are more predictable in life insurance compared to general insurance. In addition, the life results reported here do not support the agency cost hypothesis that high asset liquidity could increase agency costs for owners because managers might take advantage of the benefits of liquid assets and company performance will accordingly deteriorate (Adams and Buckle, 2000).

With respect to *unexpected inflation*, *stability of underwriting operation*, *stability of asset structure*, *assets held to cover linked liabilities to total assets* and the product mix variables, most of the results for the three measures of financial performance are insignificant and inconsistent.

The empirical results holding for all alternative regression specifications for all performance measures in terms of sign and statistical significance reveal that the performance of UK life insurers is positively related to *unexpected inflation*, and negatively related to *leverage*. The results also show that the estimated coefficient of *company size* is the only factor which is statistically significant at the 0.05 level in the models for, at least, two out of three performance measures. Thus, *company size* can be regarded as a performance determinant of UK life offices.

8.7 A Comparison of Results

In this chapter, two econometric analyses were conducted within a logical framework to identify the economic and firm-specific factors which play an important role in explaining company performance and that should be considered being included in DFA/DST applications. Nevertheless, according to the author's research experience and understanding of the insurance industry, actuaries in general identify these risk factors based on their professional judgement without recourse to any statistical or econometric analyses. This practice was confirmed at the interviews. As previously mentioned, whether professional judgement is sound has knock-on effects concerning the use of scenario and simulation modelling. In order to shed some light on the question of professional judgement, some of the survey results reported in Chapter six are compared with the findings presented in this chapter.

In Question five of the questionnaire, the respondents using scenario testing were asked whether any of the risk categories listed were included in their scenarios. Moreover, in Question six the respondents were requested to rate the importance of the possible determinants considered in the econometric analyses. This section compares the findings from this chapter and the survey results of Questions five and six presented in Chapter six. More specifically, it investigates whether the determinants identified using econometric analyses are included in the risk categories of insurers conducting scenarios testing, and whether these determinants were given highest rating of importance in terms of company performance. Finally, a number of pieces of advice to actuaries are provided.

Nevertheless, one cautionary statement should be made before the comparison is drawn. It should be noted that in this chapter the determinants were identified using annual data over the period of 1986-1999, but the main surveys were administered in May 2002. As indicated at the outset of this chapter, the determinants identified might change from one epoch to another because the financial conditions and insurance markets may have changed as the time goes by. As a result, the findings from the survey and econometric modelling are not fully comparable.

The non-life determinants identified in this Chapter are *liquidity*, *unexpected inflation* and *interest rate level*. According to the survey results presented in Table 6.8, the above-mentioned determinants were included in the scenarios by 16 per cent, 16 per cent, and 58 per cent of the respondents respectively. Table 6.9 also shows that their means of importance ratings were 2.6, 2.6, and 3.1. The life determinant identified is *company size*. This determinant was not one of the risk categories listed in the life postal survey for the respondents to choose. Its mean importance rating was 2.5 (Table 6.29).

It is worth emphasising that the determinants identified from the econometric analyses were not necessarily the risk categories which were included in the scenarios by most of the surveyed insurers conducting scenario testing, or the factors which were given highest rating of importance in terms of company performance. There could be three possible reasons behind this. The first reason is that as stated previously, the determinants might change from one epoch to another. These determinants identified using the data over the period 1986-1999 were not necessarily the risk categories or the factors which were considered important by the respondents as of the time the surveys were administered. Similarly, the factors given highest importance ratings in the surveys may not be the determinants identified using econometric analyses. For instance, *stability of underwriting operation* and *equity returns* were given the highest mean importance ratings of "3.7" and "4.2" by the non-life and life respondents respectively. Nevertheless, these factors were not found to be consistently statistically significant across the models for more than one performance measure. As discussed in Chapter two, the underwriting and investment results are the two most important factors determining profitability. For a general insurer, underwriting is its core business and is of particular importance to its overall performance. In times of booming financial markets, the good investment results can offset the bad underwriting results. As of the time the surveys were administered, interest rates were low and global equity markets were in the doldrums, making profitability through investment returns challenging and highlighting the need for improved underwriting results. This may be the reason why *stability of underwriting operation* was given the highest rating by the non-life respondents. Turning to life insurance, *equity returns* was given the highest rating since UK life offices have always invested heavily in equities. At that time, the solvency of many life insurance firms was impaired due to falling stock markets. This is perhaps the main reason why life respondents considered this factor important to their company performance.

The second reason is that the companies included in the final panel data sets for econometric analyses are not exactly the same as those in the survey populations. As indicated previously, the numbers of the companies in non-life and life panel data sets are 211 and 230 respectively, whereas the numbers of survey population are 131 and 92. The major difference between the companies in the data sets and those of survey populations is that the companies included in the data sets are those had ever existed during the period 1986-1999, but the companies in the survey populations are those existed as of the time the surveys were administered. Finally, professional judgement might be poor. Insurance operations are so complicated that on occasion actuaries were unable to apply the necessary judgement to correctly identify the risk factors facing the insurer.

Based on the findings of this section a number of pieces of advice to actuaries are provided below. First of all, since professional judgement might be poor, the actuaries charged with the task of DFA/DST should consider conducting statistical or econometric analyses to enhance professional judgement. The econometric analysis by which the important economic and firm-specific factors could be identified has been explicitly demonstrated in this Chapter. Second, due to data limitations some possible explanatory variables may have to be excluded from the econometric analysis. In this case, we would not be able to investigate the importance of these variables using econometric analyses. Therefore, professional judgement that is made based on the actuary's understanding of the insurer's risk exposure and the financial and insurance markets is still indispensable. Third, actuaries are encouraged to investigate whether the company is exposed to the risk factors listed by the actuarial professional bodies such as the Faculty and Institute of Actuaries and the Canadian Institute of Actuaries. These factors have been discussed in Chapter two. Finally, and perhaps most importantly, when building a DFA model for a particular insurer, the model builder has to consider all the risk factors identified from a variety of sources such as surveys, internal workshops, brainstorming sessions and internal auditing. Since the business of insurance is complex, some factors might be identified using one method, but not using another. Therefore, all the possible factors should be taken into account. However, the builder selects only the most important risks which have relatively greater effects on insurer performance to be modelled, based on professional judgement, prior knowledge of insurance business and markets, and existing models of similar processes.

8.8 Summary and Conclusions

In order to control for cross-industry differences in investment opportunity sets, reporting and regulatory practices, and the corresponding operating environment, two empirical analyses to identify the performance determinants of UK non-life and life insurance companies were conducted respectively using two panel data sets consisting of economic data and FSA/DTI returns over the period of 1986-1999. The non-life results show that the estimated coefficients of *liquidity, unexpected inflation* and *interest rate level* are all statistically significant at the 0.05 level in the models for, at least, two out of four performance measures. In this study, these three factors are regarded as determinants of the performance of UK non-life insurance companies and should be considered being included in DFA applications.

Over the sample period, non-life insurers with more liquid assets outperform those with less liquid assets. A piece of advice for the general insurance industry is that non-life companies should pay particular attention to the liquidity of their assets. Due to the short term nature of their business, in general a significant proportion of assets should be kept liquid in order to meet policyholders' claims. However, in the long run liquid assets produce relatively low returns. The liquid assets for each company should therefore be limited to an optimal amount or percentage.

Consistent with our prior expectations, this study finds that non-life company performance is negatively related to *unexpected inflation,* which supports the view that periods of higher *unexpected inflation* reduce financial performance for non-life companies. An implication of this finding is that it is very important for non-life companies to investigate their exposure to *unexpected inflation* and try to hedge the associated risk if necessary.

The results of the study indicate that over the sample period non-life insurer financial performance had been enhanced by increases in *interest rate level.* This evidence underlines the importance of bond returns to general insurers, confirming the findings of Browne and Hoyt (1995) who argue that US property-liability insurance companies are less likely to become insolvent during periods of high interest earnings.

Based on the same criteria mentioned above, the life results reveal that *company size* is the only determinant of the performance of UK life insurance companies. It seems clear that the "large firms" effect plays an important role in explaining UK life office performance. Since the natural logarithm of total assets was used as the size proxy, the evidence presented here supports the view that life insurers with more assets outperform those with less assets. This accords with the cited US study of Browne, Carson and Hoyt (2001) who found that larger life insurance companies produce superior financial performance.

It is worth noting that a number of measures such as the use of panel data, the choice of explanatory variables, and the treatment of three common econometric problems, were taken to ensure the validity of the findings presented in this chapter. Moreover, in order to confirm the robustness of the results, we estimated three models for each of the four performance measures in general insurance and three measures in life insurance. The consistent results in terms of sign and statistical significance were reported and discussed, while possible reasons were provided for the inconsistent results. Furthermore, the factors which were identified as performance determinants and that should be considered being included in DFA/DST applications, are those having consistent sign and significance across the models for more than one performance measure. In other words, an explanatory variable can only be regarded as a performance determinant if it has consistent sign and significance across, at least, six regression specifications. By adopting the above-mentioned measures and meeting the stringent criteria, the validity of the main results is confirmed. Nonetheless, since the determinants might change from one epoch to another, one cannot dependably extrapolate the findings as fundamentals evolve and new risks may emerge. In spite of this, the period of study has provided some genuine insights and implications for those involved in the governance of insurance firms and those within the firms who have particular responsibility for monitoring risk. Some of the insights and implications have been presented in this chapter and the remainder will be further discussed in the next chapter.

Chapter Nine

Conclusion

This thesis was centred around Dynamic Financial Analysis (DFA) / Dynamic Solvency Testing (DST) / Financial Condition Reporting (FCR). It investigated two relevant issues which were identified in Chapters two and three. These issues are mainly concerned with a number of important DFA/DST related components which are currently included in relevant applications by practitioners and the factors that may have effects on insurer performance. These two issues were then developed into the following four research questions. First, what are the current practices of DFA and FCR in the UK non-life insurance industry. Second, what are the current DST/FCR practices in the UK life insurance sector. Third, which are the economic and firm-specific factors which should be considered being included in DFA applications for a non-life insurer. Fourth, which are the economic and firm-specific factors that should be considered being included in DST for a life office. In order to address these questions of different nature three research methods were employed, including the postal survey, interview, and econometric methods.

The purpose of the final chapter of this thesis is four-fold: (1) to examine whether the aims of the research have been achieved, (2) to identify the contributions and achievements of the research, (3) to summarise the conclusions of the preceding chapters and the implications for the insurance industry, and (4) to suggest some directions for future research.

9.1 The Aims of the Research

Little is known about the extent to which DFA/DST/FCR is used by insurers. Due to the nature of the first two research questions, two postal surveys and five interviews were undertaken in order to meet the first aim of the research, which was to investigate the current practices of DFA/DST/FCR. To be more specific, this aim was to establish how widespread the use of DFA/DST/FCR is and how DFA/DST/FCR are used in the UK insurance industry. The aim was achieved, confirming that 41 per cent of the non-life companies surveyed reported using the DFA related techniques and 27 per cent producing FCR, whereas that 90 per cent of the life offices surveyed indicated employing the DST related techniques and 95 per cent preparing FCR. The ways the surveyed insurers employed DFA/DST/FCR were also discovered. Non-life firms tended to apply DFA techniques to underwriting operations, whereas their life counterparts tended to use DST techniques to investment operations. It was also found that non-life companies had shorter forecast period in DFA/business plan than life offices. Moreover, the similarities and differences of the results for different types of insurance offered were presented and discussed. It appears that with-profit offices were more capable of employing these techniques and carrying out sophisticated asset modelling than non-profit offices. In general insurance it seems that on the whole there are not many statistically significant differences in the DFA practices between the non-life firms surveyed. One difference which has been identified in the non-life analysis is that motor insurers are more likely to include liquidity in scenarios.

One of the steps in conducting DFA is to identify important performance determinants which should be considered being included in the application of DFA to a particular insurer. However, a comprehensive research on performance determinants using both FSA/DTI returns and economic data has not yet been conducted on the UK insurance industry. Two econometric analyses were conducted using two panel data sets in order to meet the second aim of the research, which was to establish which economic and firm-specific factors are important in determining non-life and life insurer performance and should be considered being included in DFA/DST applications. Four performance measures were selected in the empirical analyses to capture different aspects of insurance operations. Three models for each of four performance measures have been estimated, including ordinary least squares regression model, one-factor fixed-effects model and one-factor random-effects model. Additionally, several important econometric problems such as multicollinearity, heteroskedasticity and autocorrelation have also been addressed. The second aim was achieved by identifying a number of statistically significant determinants of company performance. The results of the study indicate that the non-life actuary must consider incorporating *liquidity*, *unexpected inflation*, and *interest rate level* in a DFA model, whereas *company size* is a determinant of life office performance.

Although actuaries should consider a variety of approaches and techniques in the circumstances of the particular company, they ultimately need to make a decision. This decision must be based on professional judgement because no single approach or technique can be demonstrated to be absolutely correct. By comparing the results from the surveys and econometric analyses, it is found that the determinants identified from the econometric analyses were not necessarily the risk categories which were included in the scenarios by most of the surveyed companies, or the factors which were given highest importance rating in terms of company performance. As discussed in the previous chapter, there are three possible explanations for this. One of the explanations is that professional judgement of actuaries might be poor. In Section 9.3.2, a piece of advice of how to enhance professional judgement is given.

9.2 The Contributions of the Research

The contributions of this research can be summarised as follows:

The first contribution of the research is to reveal the current practices of DFA/FCR of the UK insurance companies carrying on general business through a postal survey. To the author's knowledge a survey of this nature has never been administered in the non-life insurance industry before. The present study is the first one of its kind. The findings of this survey should be of value to management, the Faculty and Institute of Actuaries, and the supervisory authority. Management can compare the use of DFA techniques within their organisation with that in the whole market to assess whether there is a need to improve it, and if so, to what extent. Based on the results obtained, the Faculty and Institute of Actuaries can evaluate whether or not it is necessary to draft a Guidance Note on DFA/FCR specifically for general insurers and if so what should be its status. We will offer our opinion of this issue in Section 9.3.1. Also, from the survey results the supervisory authority is able to know the capability of the industry and accordingly set feasible requirements for non-life insurance companies when adopting risk-based approaches to regulation.

Second, an up-to-date survey was administered in order to reveal the latest DST/FCR practices of the UK insurance companies and friendly societies carrying on long-term business. Two surveys of this nature have been carried out before. The first survey which was used for investigating the practices of DST in life insurance industry, was administered in 1994 by the Dynamic Solvency Testing Working Party of the Faculty and Institute of Actuaries (1994) with a view to drafting a Guidance Note for Appointed Actuaries on FCR. The second survey was distributed in 1996 by Muir and Sarjant (1997) to discover how the life insurance industry complied with GN2 shortly after it was formally introduced into the solvency monitoring process. At that time, some life insurance companies might still have not been ready to conduct DST and prepare FCR under GN2. Moreover, the capacity of computers and the training of actuaries are more advanced and better than ever. Presumably the DST and FCR practices have changed to some extent and the proportion of companies employing relatively complicated techniques is now greater than that indicated in the reports by the Dynamic Solvency Testing Working Party and by Muir and Sarjant. The present study can serve as an update and its findings can be used to compare with those of previous studies. This study should be of interest to Appointed Actuaries, the Faculty and Institute of Actuaries, and the supervisory authority. In the life survey, nearly 90 per cent of the respondents attached their business cards with the returned questionnaire in the hope to receive a summary of the results. One respondent further commented that "*they want to* *know how they perform in this area compared with other life offices*". This indicates that on the whole Appointed Actuaries are highly interested in this survey. In addition, it has been a number of years since GN2 took effect. Some of the requirements under GN2 may be inappropriate at present. The Faculty and Institute of Actuaries could consider reviewing GN2 based on the survey results. For example, some risk factors which currently are not included in GN2, but are found important from the survey results might be considered being included. Also, a number of assumptions that are recommended to test under GN2 were found to be relatively unimportant and accordingly consideration might be given to whether to decrease their importance. A suggestion made based on the empirical results is provided in Section 9.3.1. Furthermore, by discovering the current DFA/DST/FCR practices the supervisory authority may deliver more effective and efficient regulation of the industry.

Third, this study is the first of its kind to simultaneously investigate these practices in the non-life and life sectors. By comparing and contrasting the non-life and life survey results, some conclusions concerning the use of financial techniques within these two sectors are reached. Additionally, the similarities and differences between the results for different types of insurance such as with-profit and non-profit products are presented and discussed.

Fourth, this research can be used to fill the gap in the literature on the performance determinants which are important when conducting a DFA/DST analysis. Most of previous studies which have attempted to examine performance determinants have focused on US firms. A comprehensive research on performance determinants using both FSA/DTI returns and economic data has not yet been conducted on the UK insurance industry before. The results of the research can be compared with those of previous studies in the insurance industry or other financial sectors across the world. Moreover, since in general actuaries choose risk categories which are incorporated in DFA models based on professional judgement, it would be preferable if an econometric analysis could be conducted to assist actuaries in identifying the risk factors. This present study not only illustrates how to identify the risk factors which have a material impact on company performance and that should be included in DFA/DST applications using econometric analysis, but also provides evidence of the determinants of insurer performance. Furthermore, in Section 9.3.2 some implications and advice are provided for the industry on the way forward for risk management in the insurance industry.

Fifth, in this research we have explicitly demonstrated the process of dealing with the three most commonly seen econometric problems in ordinary regression analysis, including multicollinearity, heteroskedasticity and autocorrelation. Since these econometric problems are usually ignored in applied work in the context of panel data analysis, this demonstration would be of value to actuaries who wish to identify the economic and firm-specific risk factors using panel data models.

Finally, the study provides evidence of the current DFA/DST/FCR practices and of the determinants of insurer performance, which is of value to both actuaries charged with the work of DFA modelling and insurance regulators. The components, factors, and level of detail included in relevant applications by practitioners are reported and discussed. The findings of the study could be instrumental for the actuaries in developing their own firm-specific DFA/DST models. Also, the supervisory authority would be kept informed of the industry developments in the use of DFA/DST/FCR.

9.3 Conclusions and Implications

The key conclusions obtained from the research and the implications of the results are summarised as follows:

9.3.1 Current Practices of DFA/DST/FCR of the Insurance Industry

Two postal surveys were simultaneously administered in both the non-life and the life sectors in April 2002. The results of the study indicate that the proportion of the life offices surveyed using the financial modelling techniques is greater than that of their non-life counterparts. Moreover, it appears that these life offices were more capable than non-life firms of doing asset modelling. In addition, this study also confirms that these techniques were used by less than half of the general insurers surveyed. Although general insurance is a highly technical business, actuarial involvement in this industry is not as much as that in the life insurance industry. Underwriters in the non-life sector mainly rely on their experience to underwrite policies. This was confirmed by one interviewee from a general insurer.

Compared with the earlier findings of the Dynamic Solvency Testing Working Party (1994) and Muir and Sarjant (1997), the survey results presented in this thesis show that there has been a considerable improvement in UK life offices' ability to employ financial techniques. The proportion of the sample companies which report using these techniques is much higher than that reported in previous studies. This provides further evidence of an increased level of sophistication in the approach taken by UK life insurers to the management of the risks facing them.

The study also indicates that with-profit offices tended to use more DST techniques and were more capable of doing sophisticated asset modelling than their non-profit counterparts. The main reason is that with-profit firms have relatively complicated liability structure and accordingly they usually need sophisticated asset modelling to ensure that their responsibilities to policyholders can be met. In contrast, the liability structure of non-profit offices is relatively simple. Take unit-linked business as an example. The amount of assets required to be held to meet the policyholders' liabilities is simply the sum of all the unit funds at any particular time. That is, the value of the assets and that of the liabilities are linked together and the former is always equal to the latter. Therefore, there is no possibility of insolvency (Booth et al., 1999). Also, it is shown that the assumptions concerning *allocation of profit*, *equity returns*, *asset mix* and *bonus rate* are relatively frequently tested by with-profit firms. An implication for with-profit offices who currently do not include these factors in their scenarios is that they should carefully examined whether they are unknowingly exposed to the associated risks.

Turning to the non-life results, we found that motor insurance companies are more likely to test the assumptions about *liquidity*. An implication for motor insurers is that liquidity could be one of the major risks facing insurance firms issuing motor policies. Some approaches to reducing this risk exposure are presented in Section 9.3.2. Although many observations have already been made based upon the non-life results obtained, it seems that there is no much statistically significant differentiation in the use of financial techniques between the companies offering different types of insurance. As stated previously, the main reason for very few differences in the empirical results for different types of general insurance is that the non-life sample size is relatively small. Also, this may be because most of the surveyed general insurers sold multiple types of policies, possibly because they wish to reduce underwriting risk and the amount of capital that the insurer must hold in relation to its liabilities to achieve a given level of insolvency risk. Consequently, the attributes of different types of insurance might "average out".

Of the three techniques (sensitivity testing, scenario testing and stochastic simulation) investigated in this study, scenario testing was the most popular technique both in the non-life and the life sectors. Moreover, most of the non-life and life insurers surveyed ran less than ten scenarios on a regular basis. However, it appears that scenario testing was conducted relatively frequently in non-life insurance compared to life insurance. This is probably because non-life business is more volatile than life business. It is therefore necessary for the non-life companies to conduct these tests relatively frequently. It is interesting to note that banks usually conduct scenario tests even more frequently than non-life insurance companies (Fender and Gibson, 2001). For non-life firms, frequent scenario tests sometimes become a burden and shifts in portfolio positions are relatively infrequent. This is probably the main reason why non-life firms generally run scenario tests less frequently than banks.

The survey findings show that most of the commonly seen risk categories in non-life scenarios were related to underwriting operation, whereas those in life scenarios were related to investment operation. This suggests that non-life insurance executives were relatively concerned about underwriting operation while their life counterparts investment operation. In fact, both underwriting and investment performance are very important factors shaping profitability. Insurance executives should be aware of the interrelated nature of the underwriting and investment decisions that they must make in managing their companies.

Based on the evidence obtained from the postal surveys, the life offices surveyed had longer forecast period in DST/business plan than their non-life counterparts in DFA/business plan. This is because life management usually takes a long-term view, whereas non-life management generally takes a short-term view due to the nature of business.

The analysis also reveals that the forecast period in DFA was statistically significantly correlated with that in business plan in general insurance, whereas such a relation did not exist between DST and business plan in life insurance. In fact, in the life insurance industry as a whole the DST forecast period was significantly longer than business plan projection period. Nonetheless, it should be noted that extending the forecast period of DST beyond the company's planning horizon increases the risk that business does not develop as planned, and can thus reduce the effectiveness of the analysis (Burkett, McIntyre, and Sonlin, 2001). Also, it is interesting to note that in non-profit business the forecast periods of DST and of business plan were correlated, but they were not in with-profit business.

With respect to FCR, we found that its use is relatively commonly seen in life insurance compared to general insurance. One possible explanation is that under GN2 life offices are encouraged to produce FCR and there is currently no such a Guidance Note for general insurers. Almost all life offices producing FCR prepared it annually. Similarly, most non-life firms also did it annually. Only a few respondents reported producing FCR on a monthly or quarterly basis. This evidence indicates that for those insurers producing FCR the FCR work is in general an annual exercise.

The survey results show that all the non-life respondents producing FCR made it available to their auditors, whereas about one fifth of the life respondents producing FCR did not. In addition, mixed views on the issue on the FSA's automatic access to the FCR were obtained. The proportion of the life respondents agreeing that the FSA should have automatic access to the FCR is greater than the proportion of the non-life respondents. What worries the respondents against the automatic access is the possibility of premature intervention from the FSA. However, this should not be the excuse for avoiding the FSA's automatic access. We suggest that a mechanism preventing the FSA from reacting prematurely should be in place. If such a mechanism proves to be satisfactory, the automatic access to the FCR should be offered to the FSA.

The survey findings suggest that views on whether a Guidance Note on FCR specifically for non-life insurance companies should be introduced are diverse. However, we believe that it would be desirable for the Faculty and Institute of Actuaries to issue a Guidance Note to help actuaries advising UK-supervised general insurance companies prepare an annual report on the financial condition of the company. This report could form part of the company's statutory returns or accompany the returns to the insurance regulator. As evidenced previously, 24 per cent of the non-life respondents cited *lack of relevant knowledge* as the main reason for not using DFA techniques. It seems that these techniques are relatively new to the non-life insurance industry. Non-life actuaries would be glad to have professional guidance, especially on stochastic modelling, behind them in deriving the background information underlying the FCR. It should be noted that due to the fact that every company has its own circumstances, actuaries should be left with complete discretion and be able to do whatever is necessary to their companies based on professional judgement.

We suggest that the status of such a Guidance Note on FCR for general insurers should be initially standard practice, as three fourths of the non-life respondents indicated. Since general insurers' capability of employing financial techniques generally is relatively restricted, it would become a burden for them if such a Guidance Note were made mandatory. This is particularly the case to small insurance firms. Because DFA techniques can provide regulators with important information on issues which could threaten the solvency of the company, however, we strongly recommend that this Guidance Note be made mandatory after non-life companies' ability to model assets and liabilities is greatly improved to a large extent. The actuary who is charged with the DFA task of the company, of course, should be left complete discretion. Also, such a FCR should be available to the supervisory authority at the same time as the annual FSA returns. This would enable the authorities to identify possible problems more promptly than at present. We believe that this is in line with the FSA's risk-based regulation of the insurance industry.

The survey results show that, in general, the Appointed Actuaries surveyed found that GN2 is acceptable. Nonetheless, it seems necessary to review the risk factors included in GN2 since it has taken effect since 1996. For instance, there are a number of risk factors which currently are not included in GN2 such as *asset mix* and *bonus rate*, but they were commonly seen in the scenarios used by the life offices surveyed. Due to their importance in shaping life firms' profitability, these factors should be considered being included in GN2, especially during a period of the falling equity markets and long-term interest rates. In addition, some factors which currently are included in GN2 such as *unit pricing bases* and *risk of reinsurer default* were rarely seen in the scenarios used. As a result, consideration should be given to whether to decrease their importance under GN2.

As evidenced in this study, there has been a recent trend among insurance companies towards employing stochastic modelling. There are two possible reasons behind this. The first is that due to the stochastic nature of insurance business, a DFA model must incorporate some mechanism to generate from a stochastic process the balance sheet items which have stochastic attributes. The second possible reason is that stochastic modelling is appropriate for identifying the long-term strategy for inter-related issues such as asset mix and annual bonus policy. The results of the study suggest that many actuaries are relatively unfamiliar with stochastic modelling. Nonetheless, GN2 does not provide much guidance on it. Stochastic modelling is a new and relatively undeveloped area for them. Therefore, it would be desirable for the Faculty and Institute of Actuaries to provide more relevant guidance. Although conducting stochastic modelling is ultimately a matter of judgement and computing limitations, Appointed Actuaries would be glad to have professional guidance behind them.

The survey findings show that nearly all the life offices surveyed employed the DST techniques and prepared FCR, but by contrast only a number of general insurers did. In non-life insurance *lack of need* is the main common reason why the DFA techniques were not used and why FCR was not produced. Since the FSA has adopted the risk-based approach to regulation of insurance business, risk identification has gradually become an important issue. We believe that general insurers can explicitly demonstrate to the FSA by using these techniques and preparing the FCR that they have an in-depth understanding of their risk exposures.

The importance of conducting DFA/DST was confirmed by the interview organisations. However, the qualitative evidence obtained in the interviews shows that the organisations' capability of using DFA/DST related techniques varied considerably and the ability of organisations to allow for interactions between assets and liabilities was in general restricted. All companies expressed a desire to work on or further develop their capability of stochastic modelling techniques in the coming years. It is worth noting that this is in line with the FSA's policy to encourage insurers to conduct stochastic modelling.

9.3.2 The Determinants of Insurance Company Performance

The determinants of insurer performance may be classified as belonging to one of two categories. The economic factors are those affecting all firms to some degree, while the firm-specific factors are mainly concerned with an insurer's asset and liability mix. In this study, we conducted two empirical analyses of identifying these economic and firm-specific factors which affect UK non-life and life insurer performance and that should be considered being included in DFA/DST applications.

The results of the study indicate that the performance of UK non-life insurers is positively related to *interest rate level, equity returns,* and *liquidity*, and negatively related to *unexpected inflation* and *reinsurance dependence*. It is also shown that the estimated coefficients of *liquidity, unexpected inflation* and *interest rate level* are all statistically significant and can be regarded as important determinants of general insurer performance. Three main conclusions can be drawn from the evidence presented in this study.

1. A non-life insurer with more liquid assets is more likely than a firm with less liquid assets to perform well.

2. Periods of higher *unexpected inflation* reduce financial performance for non-life companies.

3. *Interest rate level* exerts a positive impact on the performance of non-life insurers.

These findings have a number of implications for the non-life insurance industry. The first is that the statutory authority should encourage general insurers to develop liquidity risk management because asset liquidity plays an important role in general insurer performance, especially in the aftermath of the World Trade Centre attacks. In fact, investing in less liquid assets to obtain good returns could have a severely negative impact on the risk profile of a general insurer. A well-developed approach to managing liquidity risk could provide the insurer with considerable gains. There are at least two approaches to eliminating or reducing liquidity risk. The first is that the insurer can purchase financial reinsurance. This traditional reinsurance product can be used to provide an insurer with some liquidity. The second approach is to employ a collateralised external financing mechanism. This mechanism in general allows the insurer to avoid liquidation of any assets in times of market distress.

The second implication is that general insurers should pay particular attention to their exposure to unexpected inflation risk. Since the economy is gradually improving and the government adopts expansionary policies, it is very likely that unexpected inflation would occur. Therefore, approaches to hedging this risk should be available within organisations. For instance, insurers can invest part of their funds in some inflation-linked financial products that protect their fixed-income returns from the possible risk of unexpected inflation.

Third, the overall performance of general insurers may be seriously damaged during periods of low interest earnings and poor underwriting results. This is because low interest rates prevent companies making enough investment earnings to offset underwriting losses. *Interest rate level* is not a firm-specific factor, but a common factor affecting all firms in the market. An insurer should try to identify high-yielding securities with acceptable risk. However, from a risk management's viewpoint, an insurer who is expecting to receive a series of future cash inflows such as coupon payments and place them on deposit and fears a fall in interest rates might consider employing interest rate derivatives such as an interest rate floor to avoid the risk. A floor is a series of interest rate puts (floorlets) expiring on the interest payment dates. It also allows the insurer to get most of the benefit from the rise in interest rates, since the increase in interest receipts from its bank deposit is likely to be higher than the floor premium.

The final implication of these findings is that due to their importance in determining company performance the above-mentioned risk factors should be considered being included in DFA applications by model builders. For those who wish to build DFA models for their own organisations, it is important to note that these factors may change from one industry to another. For example, the risks faced by the accident & health insurance industry may not be exactly the same as those facing specialist liability insurers. Therefore, insurers specialising in a particular line of business could consider carrying out analyses using industry-specific data.

Based on the same criteria mentioned above, the empirical results reveal that the performance of UK life insurance companies is positively related to *unexpected inflation*, and negatively related to *leverage*. The results also show that the estimated coefficient of *company size* is the only factor which is statistically significant at the 0.05 level in the models for, at least, two out of three performance measures. The evidence presented here is supportive of the view that life insurance companies with more assets outperform those with less assets. This result could have important policy-making implications. Insights into the positive relation between performance and company size could help industry regulators and policy-makers to frame licensing regulations that discriminate in favour of new entrants with more assets to the market.

It is worth emphasising that model builders must not depend solely on econometric analyses although these analyses do provide them with relatively scientific results. Model builders, of course, should not necessarily exclude factors from DFA/DST modelling simply because they are not statistically significant in econometric analyses. In fact, there are other factors to which model builders should pay attention. For instance, the factors that were given high ratings in the surveys such as *stability of underwriting operation* (non-life) and *equity returns* (life) should be carefully considered when building a firm-specific model. Moreover, the factors suggested by professional bodies such as the Faculty and Institute of Actuaries may also be useful as a benchmark or reference point for insurers as they identify their own risk exposures. Furthermore, the risk factors and the findings presented in this thesis merit consideration by insurance firms and their advisers as well as by supervisors and regulators. All of them should be used as a stimulant to imaginative thinking about risk, rather than as a definitive checklist. It is worth noting that of the many aspects of the insurance process which could have material effects on an insurer's financial performance, there may be some risks factors which we are unable to model due to a lack of understanding or data. In the analysis of an insurer's financial risk exposures we, at least, have to recognise that these risks exist, even though they cannot be defined appropriately.

Professional judgement is indispensable in insurance and is a useful tool in risk assessment. It is of particular use where relevant data are scarce, for example where the risks are very firm-specific or where conditions have changed materially. According to the results presented in this research and the author's experience, most actuaries identify the risk factors faced by the company based on their own professional judgement. Due to the complexity of insurance operations, on occasion actuaries' judgement might be poor. As a result, it is an important issue on how to enhance professional judgement if it is poor. One approach to enhancing professional judgement is to set up risk management workshops or brainstorming sessions for the requisite senior management and risk takers within an organisation to identify and discuss the relevant risks, and to provide the knowledge needed to control risk throughout the organisation. Also, surveys and internal auditing are two effective methods which can be used to identify the significant hazard, financial, operational, and strategic risks faced by the insurer.

For risk management purposes, practising actuaries should identify the risk factor faced by the company. It is strongly suggested in this research that actuaries investigate if the company is exposed to the risk factors listed by actuarial professional bodies and conduct statistical or econometric analyses to assist in identifying the factors. A variety of possible factors should be considered, but actuaries ultimately need to rely on their judgement. In addition, insurance firms can consider employing scenario testing and/or stochastic modelling to demonstrate that it has sufficient financial resources to meet its expected liabilities even under stressed circumstances by assessing a wide range of assumptions about future economic and market conditions.

A final piece of advice for the insurance industry on the way forward for risk management concerns the use of integrated DFA/DST modelling. As evidenced in this study, with the exception of a few insurance companies, the non-life insurance industry is currently at an elementary stage in the development of DFA modelling. Compared with non-life companies, most life offices recognise the advantages of DST and many employ the DST techniques to assess the current solvency position of the company. However, on the whole most insurers fail to take all relevant underwriting and investment-related risk factors into account in one integrated model. Since both underwriting and investment operations are critical to the profitability, and more importantly, the solvency of insurance companies, a suitable integrated DFA/DST model is essential. Moreover, the FSA now adopts risk-based approaches to regulating insurance business. Insurance companies are encouraged to use DFA/DST to identify the risks faced by them and to assess the financial strength of the company. The pressing issue is that all insurers embark upon a plan which provides for an integrated DFA/DST model.

9.4 Avenues for Further Research

9.4.1 Current Practices of DFA/DST/FCR of the Insurance Industry

The thesis investigated two related issues on DFA/DST/FCR and some results have been produced. However, there are still a number of relevant areas of research which are worth undertaking and that would usefully build on the work within the thesis. First, a survey of all companies authorised to carry on insurance business would be beneficial in order to have a complete picture of the extent to which insurance companies use the DFA/DST related techniques and produce FCR. The data sets used in this research are SynThesys Non-Life and Life which do not consist of all the companies currently operating in the UK. By replicate the surveys using a greater volume of data, more assurance about the robustness of the results would be provided.

This thesis has provided a starting point for the analyses of current DFA/DST/FCR practices by different forms of insurance offered. A number of similarities between different types of life insurance, and between different forms of general insurance were shown respectively. It is also noted that more differences between them were identified in life insurance compared to general insurance. This may be because the non-life sample size is relatively small and the statistically significant differences, if any, would be rather difficult to obtain. Further research is clearly necessary in order to investigate whether or not there is any differentiation in the practices between different forms of general insurance offered. Of course a relatively large sample size would be necessary before such a study could take place.

In this study most of the surveyed general insurers offered more than one type of insurance. It is also very likely that the attributes of different types of insurance might "average out". It is therefore possible that general insurers of different types have varied DFA/DST/FCR practices. Another related line for further research would be to empirically investigate whether there is any significant difference between types of insurer such as reinsurer, multi-line general insurer, specialist liability insurer and specialist personal lines insurer.

As presented in Chapter seven, the interview results were compared and contrasted with the survey results. Due to a lack of data availability, such a contrast between both results aims at the validation of the survey results in a sense. Further research is necessary in order to fully validate the survey results. A relatively large-scale interview programme may be needed with a view to investigating whether or not the responses are reliable.

The survey results of the study indicate that on the whole most of the general insurers surveyed only focused on underwriting operation. Nonetheless, in non-life insurance there are two major sources of profit variability. For all types of non-life insurers, variations in claims cost are a main source of variations in profit. Moreover, variations in investment income could be another major source. Although the fact that investment income has a material effect on profit is clear to management of general insurers, it seems that the extent of the variations may not be always fully recognised. Further research is therefore necessary in order to explore the profit variability of a general insurer resulting from variations in asset returns.

9.4.2 The Determinants of Insurance Company Performance

It may be more appropriate for the actuary to consider more than one performance measure, so that the risk inherent in the business venture can be more readily understood. Different types of measure would be appropriate in different circumstances. In this study four performance measures were used in the empirical analyses regarding the identification of company performance determinants that should be considered being included in DFA/DST applications. Since insurance operations are multi-aspect and complicated, it would be desirable to employ more performance measures in order to properly assess the financial condition of a company. By so doing, the actuary can pay particular attention to the explanatory variables which are statistically significantly related to the performance measures in which the actuary is interested.

The study was carried out using the data over the period 1986-1999. During this period, the investment markets generally were bullish. Over the past three years, however, the sustained equity market falls have eroded the balance sheets of all insurers. Therefore, it would be desirable to examine how the determinants might change during a period of investment bear markets.

It is noted that most of the most appropriate models chosen in the econometric analyses are panel data models (fixed-effects or random-effects models). An implication of the results obtained from this research is that individual firm effects are important in the estimation of performance models. Therefore, future researchers might consider taking into account individual firm effects when conducting econometric modelling of UK non-life and life performance studies. It seems that in general these individual firm effects can be assumed to be time-invariant and account for any individual specific effects that are not included in the regression.

Generally speaking, the methods and techniques used in the studies of performance determinants in this research can be applied to solvency studies. Nevertheless, it should be noted that solvency rather than performance measures must be employed in such studies. The actuary has to choose appropriate measures depending on the circumstances. There are a number of common solvency-related measures such as the *probability of ruin* and the *expected policyholder deficit*. The *probability of ruin* is a usual measure with respect to insurance solvency. This measure appears reasonable from the perspective of insurance management. However, the *probability of ruin* measure is inadequate because it ignores the severity of ruin. The *expected policyholder deficit* is an enhancement to the *probability of ruin* concept in which ruin severity is also reflected. It is defined as the expected value of the difference between the amount the insurer is obligated to pay the claimant and the actual amount paid by the insurer in the event of liquidation. This measure can be used to consistently measure insolvency risk in such a way that a standard minimum level of protection is applied to all classes of policyholders and insurers (Butsic, 1994).

The actuary who wishes to conduct a study of solvency can consider including the explanatory variables considered in this research as likely determinants in such a study.

Moreover, such a study could be improved if there were other variables available. According to the work of the London Working Group of the EU Insurance Supervisors Conference, management problems appear to be the most significant risk that has threatened EU insurers' solvency during the period 1996-2002 (Sharma, 2002). It may therefore be necessary to include, for example, variables in the regression analysis which measure the extent to which management have lacked the expertise in performing their tasks properly. There are other important factors contributing to insurer insolvencies, such as operational risk, mismatch of asset and liability durations, and underwriting risk. Operational risk is difficult to measure, as was confirmed at the interview with the Statutory Reporting & Pricing Manager of Insurance Company A (Appendix C). In fact, operational risk is not just one type of risk. It is a general term used to cover many different sources of losses. We can try to quantify this risk using tools borrowed from the banking industry such as key risk indicators. First of all, the analyst should identify the main types of operational risk (e.g. distribution risk) facing the company. Then a corresponding indicator is accordingly formed (e.g. the average distribution cost). With respect to the mismatch of asset and liability durations, it could expose an insurer to liquidity risk as well as interest rate risk. Take liquidity risk as an example. As previously evidenced, this risk is of particular importance to general insurers. The asset-liability mismatch can be proxied by two separate variables as in Colquitt and Hoyt (1997) as follows: the first represents the mismatch between assets and liabilities where the resulting difference is positive; the second variable represents the absolute value of the mismatch where the resulting difference is negative. Also, many general insurers that wrote large amounts of business liability insurance failed because of underwriting risk. That is, prices and reported claim liabilities were inadequate compared to realised claim costs. This risk can be measured by the loss ratio. Finding appropriate measures of the above-mentioned risks and then including them in a solvency regression model, would be an interesting future research project.

The linear function form was used when the models were estimated. It would be interesting to try other forms to examine whether or not there exists some non-linear relationship between the explanatory variables and performance measures.

In order to avoid false significance resulting from the same denominator we were forced to exclude the two explanatory variables *leverage* and *affiliated investments* from the models for the performance measure *return on shareholders' funds*. The non-life and life results show that these two explanatory variables are not regarded as statistically significant determinants of insurance company performance. An implication of the results is that these variables are not important for company performance in terms of the measures *investment yield*, *percentage change in shareholders' funds* and *combined ratio*. Since different performance measures capture different aspects of insurance performance, *leverage* and *affiliated investments* might be important performance determinants if other performance measures were used. Therefore, using other performance measures as dependent variables and then including these two explanatory variables in the regression models to investigate whether the explanatory variables are statistically related to some performance measures would be an interesting research project.

In addition, the results reported in the studies of performance determinants also suggest one promising area of future research. As previously stated, insurance is one of the control mechanisms used to manage risks. The insurance market accepts transferred uncertainties and, through spread and volume, turns them into manageable portfolios of risks. If the risks were not managed well, it could cause company insolvency. As a result, it is important for the insurance industry to understand its risk management functions. At present actuarial activities cover a very wide range of risk management functions. Under modern conditions a dynamic approach to the management of risk is essential. The first step of risk management in insurance companies is to understand the risks to which they are exposed to remain solvent and to fulfill their obligations to policyholders. The future studies of determinants may aid the industry in understanding its risk management functions by focusing on risk identification. By identifying the important risk factors, insurance companies can then develop and select methods for managing these risks in order to increase business value to shareholders. This could involve the use of panel data analysis to study the relationship between the risks insured and the solvency status of the company. Due to the fact that premiums are paid in advance and the obligations of the company under the contracts issued are all in the future, it is likely that a lagged rather than a contemporaneous relationship would be found. In addition, there are, at least, two factors which might complicate such an analysis. First, the regulatory approach employed by the supervisory authority might have a great impact on the solvency status of the company. Second, there has been a recent trend of increased social responsibilities and correspondingly higher penalties through court awards. This will put pressure on the insurance companies and their capacity. It may therefore be necessary to include variables in the panel data analysis which measure the extent to which the company has been affected by the government and court action.

As evidenced previously, the life results show that there is only one determinant *company size* whose coefficient is statistically significant in the models for, at least, two out three performance measures. One possible explanation for the absence of the remaining variables as determinants in the life models is that the data used in this study are aggregated across lines. Future study utilising disaggregated data would further add to our understanding of the effects of these variables on insurer performance in a given marketplace.

A final avenue for further research concerns the investigation of the soundness of actuaries' professional judgement. As stated in Chapter eight, the determinants might change from one epoch to another. These determinants identified in the econometric analyses using the data over the period 1986-1999 were not necessarily the risk categories or the factors which were considered important by the respondents as of the time the surveys were administered (May 2002). It would be desirable to compare the results from the surveys with those from the econometric analyses using the data over the period, say, 2000-2002, which is closer to the time the surveys were administered. It was impossible to carry out such econometric analyses in the thesis due to data availability. As more data becomes available, such analyses may provide more robust evidence. In spite of data limitation, we feel that the evidence reported here provides some useful insights into the determination of company performance in the UK insurance industry and the important risks facing this industry, which will hopefully inspire other researchers to investigate this topic further.

In conclusion, this thesis has investigated the current practices of DFA/DST/FCR in the UK insurance industry and the risk factors that should be considered being included in DFA/DST applications. The analysis of the study has revealed some of the important components, factors and their level of detail which are currently included in relevant applications by practitioners. The industry practices revealed in this research could be used as a reference or starting point for actuaries to develop their own firm-specific DFA models. Moreover, a number of pieces of advice for the industry and the future researchers are provided. Although at present there is little empirical research on the investigation of DFA/DST/FCR practices and important risk factors in the context of insurance, adopting risk-based approaches to regulating insurance business by the supervisory authority will inevitably lead to an increase in the level of research activity in this field.

Bibliography

1. A. M. Best (1998): Best's Aggregates & Averages.
2. Adams, Mike and Mike Buckle (2000): The Determinants of Operational Performance in the Bermuda Insurance Market, Working Paper, European Business Management School, University of Wales.
3. Adams, Mike and Philip Hardwick (1999): Actuarial Surplus Determination in Life Insurance Firms: United Kingdom Evidence, Occasional Paper: Number 6, Association of British Insurers.
4. Almagro, Manuel and Sonlin, Stephen M. (1995): An Approach to Evaluating Asset Allocation Strategies for Property/Casualty Insurance Companies, Casualty Actuarial Society Discussion Paper Program, pp. 55-79.
5. Amihud, Y. (1996): Unexpected Inflation and Stock Returns Revised- Evidence from Israel", Journal of Money Credit and Banking, Vol. 28, pp. 22-33.
6. Arabeyre, Valérie and Stephen Hardwick (2001): From Embedded Value to Share Price, Emphasis (Jan/2001) published by Tillinghast-Towers Perrin.
7. Australian Prudential Regulation Authority (2000): Draft Prudential Standard on Capital Adequacy for General Insurers (released on July 28, 2000). The document is available at http://www.apra.gov.au/mediareleases
8. Balestra, Pietro (1996): Introduction to Linear Models for Panel Data, in "The Econometrics of Panel Data: Handbook of the Theory with Applications" edited by László Mátyás and Patrick Sevestre, second edition (Kluwer Academic Publishers; Netherlands).
9. Baltagi, Badi H. (1995): Econometric Analysis of Panel Data, first edition (John Wiley and Sons; UK)
10. Bannister, Jim (1997): Insurance Solvency Analysis, second edition (LLP Professional Publishing; UK)
11. Basel Committee on Banking Supervision (2001): Overview of the New Basel Accord. This document is available at http://www.bis.org/publ/bcbsca02.pdf.

12. Beard, R. E. (1964): Some Thoughts on the Solvency of Insurance Companies, Algemene Reinsurance Companies Jubilee Letter No. 1.
13. Berger, Allen N., J. David Cummins and Mary A. Weiss (1997): The Coexistence of Multiple Distribution Systems for Financial Services: The Case of Property-Liability Insurance, Journal of Business, Vol. 70, No. 4, pp. 515-546.
14. Berketi, Alexandra (1998): Allowing for Insurance Companies' Liabilities in Mean-Variance Models, PhD Thesis, Herriot-Watt University, UK.
15. Birkmaier, Ulrike and Helfenstein, Rainer (2000): Europe in Focus: Non-life Markets Undergoing Structural Change, Swiss Re, Sigma, No. 3/2000, pp. 1-41.
16. Blaikie, N. (1993): Approaches to Social Enquiry (Polity Press; UK).
17. Bogen, Karen (1996): The Effect of Questionnaire Length on Response Rates--A Review of the Literature. This document is available at http://www.census.gov/srd/papers/pdf/kb9601.pdf
18. Bohra, R. and T. Weist (2001): Preliminary Due Diligence of DFA Insurance Company, Casualty Actuarial Society Forum, pp. 25-58.
19. Booth, P., R. Chadburn, D. Cooper, S. Haberman and D. James (1999): Modern Actuarial Theory and Practice (Chapman & Hall; UK).
20. Boulton, David and Martyn Hammersley (1996): Analysis of Unstructured Data, in "Data Collection and Analysis", edited by Roger Sapsford and Victor Jupp, first edition (Sage Publications; UK).
21. Bowers, N. L. et al. (1997): Actuarial Mathematics, second edition (Society of Actuaries; USA)
22. Brealey, Richard A. and Stewart C. Myers (2000): Principles of Corporate Finance, sixth edition (McGraw-Hill; UK).
23. Breusch, T. S. and A. R. Pagan (1980): The LM Test and its Application to Model Specification in Econometrics, Review of Economic Studies, Vol. 47, pp. 239-254.
24. Briys, Eric and Francois de Varenne (2001): Insurance From Underwriting to Derivatives (Wiley; UK).

25. Browne, Mark J. and Robert E. Hoyt (1995): Economic and Market Predictors of Insolvencies in the Property-Liability Insurance Industry, The Journal of Risk and Insurance, Vol. 62, No. 2, pp. 309-327.
26. Browne, Mark J., James M. Carson and Robert E. Hoyt (1999): Economic and Market Predictors of Insolvencies in the Life-Health Insurance Industry, The Journal of Risk and Insurance, Vol. 66, No. 4, pp. 643-659.
27. Browne, Mark J., James M. Carson and Robert E. Hoyt (2001): Dynamic Financial Models of Life Insurers, North American Actuarial Journal, Vol. 5, No. 2, pp. 11-26.
28. Burkett, John C., McIntyre, Thomas S. and Sonlin, Stephen M. (2001): DFA Insurance Company Case Study, Part I: Reinsurance and Asset Allocation, Casualty Actuarial Society Forum, pp. 59-98.
29. Butsic, Robert P. (1994): Solvency Measurement for Property-Liability Risk-Based Capital Applications, The Journal of Risk and Insurance, Vol. 61, No. 4, pp. 656-690.
30. Cabral, Luis (1995): Sunk Costs, Firm Size and Firm Growth, Journal of Industrial Economics, Vol. 43, No. 2, pp. 161-172.
31. Canadian Institute of Actuaries (1991): Standard of Practice on Dynamic Solvency Testing for Life Insurance Companies (in effect January 1, 1992). This document is available at http://www.actuaries.ca/publications/sop_e.html
32. Canadian Institute of Actuaries (1993): Standard of Practice on Dynamic Solvency Testing for Fraternal Benefits Society (in effect January 1, 1994). This document is available at http://www.actuaries.ca/publications/sop_e.html
33. Canadian Institute of Actuaries (1998): Standard of Practice on Dynamic Capital Adequacy Testing (in effect January 1, 1999). This document is available at http://www.actuaries.ca/publications/sop_e.html
34. Canadian Institute of Actuaries (2000): Considerations in the Determination of Embedded Value for Public Disclosure in Canada, Draft Paper. This document is available at http://www.actuaries.ca/structure/PSC/RAVA/Embedded_Value-e.pdf.

35. Cariño et al. (1994): The Russel-Yasuda Kasai Model: An Asset Liability Model for a Japanese Insurance Company using Multi-Stage Stochastic Programming, Interfaces, Vol. 24, pp. 29-49.
36. Cariño, D. R. and W. T. Ziemba (1998): Formulation of the Russel-Yasuda Kasai Financial Planning Model, Operations Research, Vol. 46, No. 4, pp. 433-449.
37. Cariño, D. R., D. H. Myers and W. T. Ziemba (1998): Concepts, Technical Issues, and Uses of the Russel-Yasuda Kasai Financial Planning Model, Operations Research, Vol. 46, No. 4, pp. 450-462.
38. Carson, James M. and Robert E. Hoyt (1992): An Econometric Analysis of Changes in the Demand for life Insurance Policy Loans, The Journal of Risk and Insurance, Vol. 59, pp. 239-251.
39. Carson, James M. and Robert E. Hoyt (1995): Life Insurer Financial Distress: Classification Models and Empirical Evidence, The Journal of Risk and Insurance, Vol. 62, No. 4, pp. 764-775.
40. Casualty Actuarial Society (1990): Foundations of Casualty Actuarial Science, USA.
41. Casualty Actuarial Society (2000): Dynamic Financial Analysis Research Handbook. This document is available at http://www.casact.org/research/dfa/index.html.
42. Christofides, S. (2000): Discussion of "Corporate Decisions in General Insurance: Beyond the Frontier" by M. P. Cumberworth, A. N. Hitchcox, W. D. McConnell and A. D. Smith, British Actuarial Journal, Vol. 6, II, pp. 259-296.
43. Christofides, S. and A. D. Smith (2001): DFA- The Value of Risk, Casualty Actuarial Society Forum, pp. 153-194.
44. Codoni, Camille (2000): World Insurance in 1999: Soaring Life Insurance Business, Swiss Re, Sigma, No. 9/2000, pp. 1-34.
45. Codoni, Camille (2001): World Insurance in 2000: Another Boom Year for Life Insurance; Return to Normal Growth for Non-Life Insurance, Swiss Re, Sigma, No. 6/2001, pp. 1-38.
46. Colquitt, L. L. and Robert E. Hoyt (1997): Determinants of Corporate Hedging Behavior: Evidence from the Life Insurance Industry, The Journal of Risk and Insurance, Vol. 64, pp. 649-671.

47. Consigli, Giorgio (1998): Dynamic Stochastic Programming for Asset and Liability Management, PhD Thesis, University of Essex, UK.
48. Correnti, S and John C. Sweeney (1994): Asset-Liability Management and Asset Allocation for Property and Casualty Companies- The Final Frontier, Proceedings of the 4th Actuarial Approach for Financial Risks International Colloquium, Vol. 2, pp. 907-918.
49. Correnti, S, P. A. Nealon and S M. Sonlin (1996): Decomposing Risk to Enhance ALM and Business Decision Making for Insurance Companies, Proceedings of the 6th Actuarial Approach for Financial Risks International Colloquium, pp. 443-472. .
50. Correnti, S., Stephen M. Sonlin and Daniel B. Isaac (1998): Applying a DFA Model to Improve Strategic Business Decisions, Casualty Actuarial Society Forum, pp. 15-51.
51. Cox, J.C., Ingersoll, J.E. and Ross, S. A. (1985): A Theory of the Term Structure of Interest Rates, Econometrica, Vol. 53, pp. 385-407.
52. Cumberworth, M. P., Hitchcox, A. N., McConnell, W. D. and Smith, A. D. (2000): Corporate Decisions in General Insurance: Beyond the Frontier, British Actuarial Journal, Vol. 6, II, pp. 259-296.
53. D'Arcy, Stephen P., Gorvett, Richard W., Herbers, Joseph A., Hettinger, Thomas E., Lehmann, Steven G. and Miller, Michael J. (1997): Building a Public Access PC-Based DFA Model, Casualty Actuarial Society Forum, pp. 1-40.
54. D'Arcy, Stephen P., Gorvett, Richard W., Hettinger, Thomas E. and Walling, Robert J. (1998): Using the Public Access DFA Model: A Case Study, Casualty Actuarial Society Forum, pp. 53-118.
55. Daykin et al. (1987): Assessing the Solvency and Financial Strength of a General Insurance Company, Journal of the Institute of Actuaries, Vol. 114, Part 2, pp. 227-325.
56. Daykin et al. (1990): Managing Uncertainty in a General Insurance Company, Journal of the Institute of Actuaries, Vol. 117, Part 2, pp. 173-277.

57. Daykin, C. D. and Bernstein, G. D. (1985): A Simulation Model to Examine Questions of Solvency in the Light of Asset and Run-off Risks. The paper was presented to ASTIN Colloquium in Biarritz in October 1985.

58. Daykin, C. D., T. Pentikäinen and M. Pesonen (1994): Practical Risk Theory for Actuaries, fist edition (Chapmean & Hall; UK).

59. De Vaus, David (2002): Surveys in Social Research, fifth edition (Routledge; UK)

60. Diggle, P. J., K. Y Liang and S. L. Zegar (1994): Analysis of Longitudinal Data, (Oxford Clarendon Press; UK)

61. Dillman, D. A. (2000): Mail and Internet Surveys: The Total Design Method (Wiley; USA)

62. Doherty, Neil and H. B. Kang (1988): Interest Rates and Insurance Price Cycles, Journal of Banking and Finance, Vol. 12, pp. 199-214.

63. Dynamic Solvency Testing Working Party (1994): Dynamic Solvency Testing, in the Proceedings of Current Issues in Life Assurance, Seminar, 2 November 1994, the Faculty and Institute of Actuaries.

64. Enz, Rudolf and Karl, Kurt (2001): Profitability of the Non-Life Insurance Industry: It's Back-to-Basics Time, Swiss Re, Sigma, No. 5/2001, pp. 1-37.

65. Evans, David S. (1987): The Relation Between Firm Growth, Size and Age: Estimates for 100 Manufacturing Industries, Journal of Industrial Economics, Vol. 35, No. 4, pp. 567-581.

66. Faculty and Institute of Actuaries (1996): Guidance Note 2: Financial Condition Reports. This document is available at http://www.actuaries.org.uk/map/GN02V1-0.pdf.

67. Fama, Eugene F. and Schwert, G. W. (1977): Asset Returns and Inflation, Journal of Financial Economics, Vol. 5, pp. 115-146.

68. Feige, Edgar L. and P. A. V. B. Swamy (1974): A Random Coefficient Model of the Demand for Liquid Assets, Journal of Money, Credit, and Banking, Vol. 6, No. 2, pp. 241-252.

69. Feldblum, Sholom (1992): European Approaches to Insurance Solvency, Casualty Actuarial Society Discussion Paper Program, pp. 511-552.

70. Feldblum, Sholom (1995): Forecasting the Future: Stochastic Simulation and Scenario Testing, Casualty Actuarial Society Discussion Paper Program, pp. 151-178.
71. Fender, Ingo and Michael S. Gibson (2001): Stress Testing in Practice: A Survey of 43 Major Financial Institutions, BIS (Bank for International Settlements) Quarterly Review, June, pp. 58-61.
72. Financial Services Authority (1998): Explanatory Guidance to Authorised Insurance Companies on the Preparation of Annual Returns to Insurance Directorate of HM Treasury.
73. Financial Services Authority (2001a): Integrated Prudential Sourcebook. This document is available at http://www.fsa.gov.uk/pubs/cp/cp97.pdf.
74. Financial Services Authority (2001b): The Future Regulation of Insurance. This document is available at http://www.fsa.gov.uk/pubs/other/future-reg_insurance.pdf.
75. Financial Services Authority (2002a): Liquidity Risk in the Integrated Prudential Sourcebook: Systems and Control Chapter. This document is available at http://www.fsa.gov.uk/pubs/cp/cp128.pdf.
76. Financial Services Authority (2002b): The FSA Handbook. This document is available at http://www.fsa.gov.uk/handbook/.
77. Franklin, P. J. and Woodhead, C. (1980): The UK Life Assurance Industry (Croom Helm Ltd; U.K.)
78. Frech, H. E. and J. C. Samprone (1980): The Welfare Loss of Excess Non-price Competition: The Case of Property- Liability Insurance Regulations, Journal of Law and Economics, Vol. 13, pp. 429-440.
79. Giammarino, Ronald (1998): Central Bank Policy, Inflation, and Stock Prices. This document is available at http://www.bank-banque-canada.ca/publications/conf/con98/cn98-9.pdf.
80. Gillham, B. (2000): Developing a Questionnaire (Continuum; UK).
81. Gorvett, Richard Wayne (1998): Dynamic Financial Analysis of Property-Liability Insurance Companies, PhD Thesis, University of Illinois at Urbana-Champaign.

82. Greene, William H. (1998): LIMDEP, version 7.0, User's Manual, revised edition (Econometrics Software, Inc.; USA).
83. Greene, William H. (2000): Econometric Analysis, fourth edition (Prentice Hall; USA).
84. H M Treasury (2001): Insurance Annual Report 2000 (The Stationery Office; UK).
85. Hall, Bronwyn H. (1987): The Relationship Between Firm Size and Firm Growth in the US Manufacturing Sector, Journal of Industrial Economics, Vol. 35, No. 4, pp. 583-606.
86. Hanfling, Oswald (1981): Logical Positivism (Oxford Blackwell; UK).
87. Hardwick, Philip and Mike Adams (1999): Firm Size and Growth in the United Kingdom Life Insurance Industry, Occasional Paper: Number 9, Association of British Insurers.
88. Hardwick, Philip and Mike Adams (1999): The Determinants of Financial Derivatives Use in the United Kingdom Life Insurance Industry, Occasional Paper: Number 5, Association of British Insurers.
89. Hardy, M. R. (1993): Stochastic Simulation in Life Office Solvency Assessment, Journal of Institute of Actuaries, Vol. 120, pp. 131-151.
90. Hardy, M. R. (1996): Simulating the Relative Solvency of Life Insurers, British Actuarial Journal, Vol. 2, No. IV, pp. 1003-1019.
91. Hausman, J. A. (1978): Specification Tests in Econometrics, Econometrica, Vol. 46, No. 6, pp. 1251-1271.
92. Helfenstein, Rainer (1999): World Insurance in 1997: Booming Life Insurance Business, but Stagnating Non-Life Business, Swiss Re, Sigma, No. 3/1999, pp. 1-30.
93. Hendry, D. F. and Richard, J. F. (1983): The Econometric Analysis of Economic Time Series, International Statistical Review, Vol. 51, pp. 111-163.
94. Hodes, Douglas M., Feldblum, Sholom and Neghaiwi, Antoine A. (1999): The Financial Modelling of Property-Casualty Insurance Companies, North American Actuarial Journal, Vol.3, No. 3, pp. 41-69.
95. Hsiao, Cheng (1986): Analysis of Panel Data, first edition (Cambridge University Press; USA).

96. Insurance Companies Act 1982, HMSO.
97. Insurance Directory- the Definitive Guide to Insurance Industry 2002, Timothy Benn Publishing Ltd.
98. Judge, George G., William E. Griffiths, R. Carter Hill and Tsoung-Chao Lee (1980): The Theory and Practice of Econometrics, first edition (John Wiley and Sons; USA).
99. Kaufman, Allan M., Thomas A. Ryan (2000): Strategic Asset Allocation for Multi-Line Insurers Using Dynamic Financial Analysis, Casualty Actuarial Society Forum, pp. 1-20.
100. Kaufmann, R., Gadmer, A. and Klett, R. (2001): Introduction to Dynamic Financial Analysis, Astin Bulletin, Vol. 31, No. 1, pp. 213-249.
101. Kennedy, P. (1998): A Guide to Econometrics, fourth edition (Blackwell; USA).
102. Klugman, Stuart A., Harry H. Panjer, Gordon E. Willmot (1998): Loss Models: Form Data to Decisions, first edition (John Wiley & Sons; USA).
103. Klumpes, Paul J. M. (2000): Alternative Performance Measures of Life Insurance Firms for Management Control and Performance Management: Evidence From Australia and the UK, Occasional Paper: Number 10, Association of British Insurers.
104. KPMG (1999): Proposal in Relation to a Scheme of Arrangement between Sovereign Marine & General Insurance Company Limited and its Scheme Creditors.
105. Krouse, C. G. (1970): Portfolio Balancing Corporate Assets and Liabilities with Special Application to Insurance Management, Journal of Financial and Quantitative Analysis, Vol. 5, Issue 1, pp. 77-104.
106. Kuhn, T. (1970): The Structure of Scientific Revolutions (University of Chicago Press; USA).
107. Lamm-Tennant, Joan and Laura T. Starks (1993): Stock versus Mutual Ownership Structures: The Risk Implications, Journal of Business, Vol. 66, No. 1, pp. 29-46.
108. Laster, David and A. E. Thorlacius (2000): Asset-liability Management for Insurers, Swiss Re, Sigma No. 6/2000, pp. 1-36.

109. Limb, A. P. (1984): The Solvency of Life Assurance Companies". A Report of Working Party to the Faculty of Actuaries.

110. Lowe, S. P. and J. N. Stanard (1996): An Integrated Dynamic Financial Analysis and Decision Support System for a Property Catastrophe Reinsurer, Casualty Actuarial Society Forum, pp. 89-118.

111. Macdonald, A. S. (1995): A Stochastic Evaluation of Solvency Valuations for Life Offices, PhD Thesis, Herriot-Watt University, UK.

112. Maddala, G. S. (1993): The Econometrics of Panel Data (Elgar; UK).

113. Mango, Donald F. and J. M. Mulvey (2000): Capital Adequacy and Allocation Using Dynamic Financial Analysis, Casualty Actuarial Society Forum, pp. 55-76.

114. Modigliani, F. and M. H. Miller (1958): The Cost of Capital, Corporation Finance and the Theory of Investment, American Economic Review, Vol. 48, pp. 261-297.

115. Muir, Martin and Sarjant, Steve (1997): Dynamic Solvency Testing. This paper was presented to the Staple Inn Actuarial Society on 4 March 1997.

116. Mulvey, John M. and Thorlacius, A. Eric (1998): The Towers Perrin Global Capital market Scenario Generation System, in World Wide Asset and Liability Modelling, edited by W. Ziemba and Mulvey J., first edition (Cambridge University Press; UK)

117. Munch, P. and D. Smallwood (1980): Solvency Regulation in the Property-Casualty Insurance Industry: Empirical Evidence, Bell Journal of Economics, Vol. 11, pp. 261-279.

118. National Association of Insurance Commissioners (2001a): Insurance Regulatory Information System: Property/Casualty Edition. This document is available at http://www.naic.org/1finance/iris/docs/UIR-PB_01_web.pdf.

119. National Association of Insurance Commissioners (2001b): Insurance Regulatory Information System: Life/Health Edition. This document is available at http://www.naic.org/1finance/iris/docs/UIR-LB_01_web.pdf.

120. National Association of Insurance Commissioners (2001c): Insurance Regulatory Information System: Fraternal Edition. This document is available at http://www.naic.org/1finance/iris/docs/UIR-FB_01_web.pdf.

121. Oakden, Friedland and Périgny (2001): Dynamic Capital Adequacy Survey, Tillinghast- Towers Perrin. This document is available at http://www.actuaries.ca/meetings/aa/2001/I_Perigny.pdf

122. Office for National Statistics (2001a): National Statistics (The Stationery Office; U.K.). This document is available at http://www.statistics.gov.uk

123. Office for National Statistics (2001b): United Kingdom National Accounts- The Blue Book (The Stationery Office; U.K.). This document is available at http://www.statistics.gov.uk

124. Olsen, Kevin J. (2001): Surplus Allocation: A DFA Application, Casualty Actuarial Society Forum, pp. 659-703.

125. Ong, A. S. K. (1995): Asset Allocation Decision Models in Life Insurance, Ph.D. Thesis, City University, UK.

126. Outreville, J. F. (1990): Whole Life Lapse Rates and the Emergency Fund Hypothesis, Insurance: Mathematics and Economics, Vol. 9, pp. 249-255.

127. Patton, M. Q. (1982): Practical evaluation (Sage Publications; USA).

128. Pearce, Douglas K. and R. Vance Roley (1988): Firm Characteristics, Unanticipated Inflation, and Stock Returns, The Journal of Finance, Vol. 43, No. 4, pp. 965-981.

129. Pentikäinen and Rantala (1982): Solvency of Insurers and Equalization Reserves (Insurance Publishing Company; Helsinki).

130. Pentikäinen et al. (1989): Insurance Solvency and Financial Strength (Insurance Publishing Company; Helsinki).

131. Pentikäinen, Teivo (1988): On the Solvency of Insurers, in Cummins, J. D. and Derrig, R. (editors): Classical Insurance Solvency Theory (Kluwer Academic Publishers; U.S.A.).

132. Philbrick, Stephen W. and Painter, Robert A. (2001): DFA Insurance Company Case Study, Part II: Capital Adequacy and Capital Allocation, Casualty Actuarial Society Forum, pp. 99-151.

133. Philpott, John (2000): The Insurance Companies (Accounts and Statements) Regulations 1996- A Practical Guide and Commentary, third edition (Ernst & Young; UK)

134. Pindyck, Robert S. and Daniel L. Rubinfeld (1998): Econometric Models and Economic Forecasts, fourth edition (Irwin McGraw-Hill; USA).

135. Post Index 2000 (2000): first edition (Timothy Benn Publishing ; UK).

136. Pricewaterhousecoopers (2001): Insurance Review (May).

137. Reilly, F. (1997): The Impact of Inflation on ROE, Growth and Stock Prices, Financial Services Review, Vol. 6, No. 1, pp. 3-17.

138. Resmini, Laura (2000): The Determinants of Foreign Direct Investment in the CEECs, Economics of Transition, Vol. 8, No.3, pp. 665-689.

139. Ross, M. D. (1991): Modelling a With-Profits Life Office, Journal of the Institute of Actuaries, Vol. 116, pp. 691-715.

140. Ross, M. D. and M. R. McWhirter (1991): The Impact on Solvency and Policy Results of the Valuation Regulations Restrictions on Equity Yields. Unpublished paper.

141. Ryan, et al. (2001): Financial Condition Assessment. This paper was presented to the Institute of Actuaries on 26 March 2001.

142. Ryan, John P. (1984): Application of Simulation Techniques to Solvency Testing for a Non-life Office, Transactions of the 22nd International Congress of Actuaries, Vol. 3, pp. 269-277.

143. Sarantakos, S. (1998): Social Research, second edition (Macmillan Press; UK).

144. Sharma, P. (2002): Prudential Supervision of Insurance Undertakings: Report of the London Working Group on Solvency II. Conference of the Insurance Supervisory Services of the Member States of the European Union, Paris.

145. Smith, Bruce D. and Michael J. Stutzer (1990): Adverse Selection, Aggregate Uncertainty, and the Role for Mutual Insurance Companies, Journal of Business, Vol. 63, No. 4, pp. 493-510.

146. Society of Actuaries (1996): Dynamic Financial Condition Analysis Handbook (Society of Actuaries; USA).

147. Staking, Kim B. and David F. Babbel (1995): The Relation Between Capital Structure, Interest Rate Sensitivity and Market Value in the Property-Liability Insurance Industry, The Journal of Risk and Insurance, Vol. 62, No. 4, pp. 690-718.

148. Standard & Poor's Thesys (2001a): 1999 SynThesys Non-Life User Guide.

149. Standard & Poor's Thesys (2001b): 1999 SynThesys Life User Guide.

150. Studenmund, A. H. (1997): Using Econometrics: A Practical Guide, third edition (Addison-Wesley Educational Publishers; USA).

151. Swamy, P.A.V.B., James R. Barth, Ray Y. Chou, and John S. Jahera, Jr. (1996): Determinants of U.S. Commercial Bank Performance: Regulatory and Econometric Issues, Research in Finance, Vol. 14, pp. 117-156.

152. Sweeney, John C. et al. (1998): Optimal Insurance Asset Allocation in a Multi-Currency Environment, in World Wide Asset and Liability Modelling, edited by W. Ziemba and Mulvey J., first edition (Cambridge University Press; U.K.)

153. Szkoda, Susan et al. (1995): CAS Dynamic Financial Analysis Handbook, Release 1.0 (Final) (Casualty Actuarial Society; U.S.A.).

154. The Actuarial Directory 2002, The Faculty and Institute of Actuaries.

155. The Baird Report 2001, The Stationery Office.

156. The Insurance Companies (Accounts and Statements) Regulations 1996, HMSO.

157. Thomas, R. L. (1997): Modern Econometrics, first edition (Addison-Wesley; USA).

158. Troxel, T. E. and G. E. Bouchie (1995): Property-Liability Insurance Accounting and Finance, fourth edition (American Institute for Chartered Property Casualty Underwriters; U.S.A.)

159. Tschoegl, Adrian E. (1983): Size, Growth, and Transnationality among the World's Largest Banks, Journal of Business, Vol. 56, No. 2, pp. 187-201.

160. Walling, Robert J., Hettinger, Thomas E., Emma, Charles C. and Ackerman, Shawna (1999): Customising the Public Access Model Using Publicly Available Data, Casualty Actuarial Society Forum, pp. 239-266.

161. Wass, V. J. and Wells, P. E. (1994): Principles and Practice in Business and Management Research (Aldershot; UK)

162. Wilkie, A.D. (1986): A Stochastic Investment Model for Actuarial Use, Transactions of Faculty of Actuaries, Vol. 39, pp. 341-403

163. Wilkie, A.D. (1995): More on a Stochastic Model for Actuarial Use, British Actuarial Journal, Vol. 1, Part V, pp. 777-964

164. Witcraft, S. E. (1998): Profitability Targets: DFA Provides Probability Estimates, Casualty Actuarial Society Forum, pp. 273-302.

165. Yin, Robert K. (1994): Case Study Research—Design and Methods, second edition (SAGE; USA).

Appendix A: Consolidated Financial Statements, Key Ratios and their Definitions

Appendix A1: Consolidated financial statements and key ratios of the UK insurance industry

A1.1 Non-life insurance industry

Table A1.1.1: Consolidated technical account of the UK non-life insurance industry (1985-1999)

Unit: £000	1985	1986	1987	1988	1989
Gross premiums written	13896890	16539724	17444468	18968052	21339513
Reinsurance ceded	3240715	3635909	3213999	3288149	3721926
Net premiums written	10656175	12903815	14230469	15679903	17617587
Increase in premiums reserve	555080	852023	922428	938134	805543
Net premiums earned	10101095	12051792	13308041	14741769	16812044
Net claims incurred	7451368	8203461	9365566	9737401	11827642
Claims management costs	272367	311551	349852	417508	471947
Commissions	2066389	2292791	2441172	2711697	3179800
Other acquisition expenses	325740	357391	390154	518483	608333
Administrative expenses	984454	1096746	1218481	1363643	1606568
Reinsurers' commissions & profit participations	536714	516325	477083	492736	552940
Net operating expenses	3112236	3542154	3922576	4518595	5313708
Adjustments for discounting	0	0	0	0	0
Change in technical provisions	847168	1258681	923898	456003	786327
Increase in provision for unexpired risks	21761	17185	17328	37190	38311
Other technical income or charges	-8786	13137	12300	-34338	770
Underwriting profit	-1340224	-956552	-909027	-41758	-1153174

Table A1.1.1: Consolidated technical account of the UK non-life insurance industry (1985-1999) (continued)

Unit: £000	1990	1991	1992	1993	1994
Gross premiums written	23447261	26450646	29673916	32678100	32353450
Reinsurance ceded	4788186	5647773	6851795	7467352	7401575
Net premiums written	18659075	20802873	22822121	25210748	24951875
Increase in premiums reserve	597799	663251	853110	924345	261919
Net premiums earned	18061276	20139622	21969011	24286403	24689956
Net claims incurred	15815726	18541258	18029345	17916199	15412310
Claims management costs	562153	658436	635297	654820	732181
Commissions	3607853	4059895	4561200	4970823	5112955
Other acquisition expenses	691524	675056	979588	992998	1039318
Administrative expenses	1875273	2055580	1932492	1994316	2125794
Reinsurers' commissions & profit participations	619724	720218	887928	1063412	1129574
Net operating expenses	6117079	6728749	7220649	7549545	7880674
Adjustments for discounting	0	0	0	0	0
Change in technical provisions	460548	1196841	662313	1003483	1241524
Increase in provision for unexpired risks	10449	82011	478487	-246738	-58419
Other technical income or charges	31516	29110	17818	-81009	-65549
Underwriting profit	-4311010	-6380127	-4403965	-2017095	148318

Table A1.1.1: Consolidated technical account of the UK non-life insurance industry (1985-1999) (continued)

Unit: £000	1995	1996	1997	1998	1999
Gross premiums written	33884901	41410652	31511358	30071854	31430180
Reinsurance ceded	7766741	6999833	7080078	6251258	7220962
Net premiums written	26118160	34410819	24431280	23820596	24209218
Increase in premiums reserve	145176	319579	616922	475436	468683
Net premiums earned	25972984	34091240	23814358	23345160	23740535
Net claims incurred	16048847	16343859	17808579	18945027	19196444
Claims management costs	799799	892264	1163888	1185828	1160110
Commissions	5419945	5002739	4892547	5027924	5281436
Other acquisition expenses	1173353	1516622	1471056	1488647	1389260
Administrative expenses	2234410	1929661	2233652	2324646	2414384
Reinsurers' commissions & profit participations	1248279	1052635	908882	933990	958967
Net operating expenses	8379228	8288651	8852261	9093055	9286223
Adjustments for discounting	-21531	-8310	48205	-37692	-14095
Change in technical provisions	2002522	10427186	-279317	-1068366	-1570945
Increase in provision for unexpired risks	-61862	-104094	-113951	67937	-72441
Other technical income or charges	84475	88369	45422	40705	-1115
Underwriting profit	-332807	-784303	-2359587	-3689480	-3113956

Table A1.1.2: Consolidated non-technical account of the UK non-life insurance industry (1985-1999)

Unit:£000	1985	1986	1987	1988	1989
Underwriting profit	-1340224	-956552	-909027	-41758	-1153174
Net investment income	1380907	1576690	1681023	1986945	2637234
Net realised gains	0	0	0	0	0
Other income	266988	428273	429338	369795	609373
Pre-tax profit	307671	1048411	1201334	2314982	2093433
Tax on profit or loss	29693	241924	276874	600906	466720
After-tax profit	272262	809245	921219	1707492	1628308
Extraordinary profit or loss	0	0	0	0	0
Tax on extraordinary profit or loss	0	0	0	0	0
Other taxes	0	0	0	0	0
Profit or loss for the financial year	272262	809245	921219	1707492	1628308
Dividends (paid and proposed)	461302	641735	718124	997076	1305451
Profit or loss retained for the financial year	-189040	167510	203095	710416	322857

Table A1.1.2: Consolidated non-technical account of the UK non-life insurance industry (1985-1999) (continued)

Unit:£000	1990	1991	1992	1993	1994
Underwriting profit	-4311010	-6380127	-4403965	-2017095	148318
Net investment income	2873776	2835980	2854286	2948573	2817095
Net realised gains	0	0	0	0	0
Other income	539641	699529	1127114	936532	311204
Pre-tax profit	-897593	-2844618	-422565	1868010	3276617
Tax on profit or loss	-305181	-401604	-224716	217766	647984
After-tax profit	-606078	-2556434	-188116	1585202	2607044
Extraordinary profit or loss	0	0	0	0	0
Tax on extraordinary profit or loss	0	0	0	0	0
Other taxes	0	0	0	0	0
Profit or loss for the financial year	-606078	-2556434	-188116	1585202	2607044
Dividends (paid and proposed)	1296063	995540	1259242	1454821	1591201
Profit or loss retained for the financial year	-1902141	-3551974	-1447358	130381	1015843

Table A1.1.2: Consolidated non-technical account of the UK non-life insurance industry (1985-1999) (continued)

Unit:£000	1995	1996	1997	1998	1999
Underwriting profit	-332807	-784303	-2359587	-3689480	-3113956
Net investment income	4051501	3845847	4731644	4708359	3819434
Net realised gains	588941	907258	1143200	3154987	2046683
Other income	384861	837259	457356	592429	344420
Pre-tax profit	4692496	4806061	3972613	4766295	3096581
Tax on profit or loss	1057301	790421	1077252	911004	467592
After-tax profit	7801704	3805575	6037633	9564415	2274658
Extraordinary profit or loss	7607	104	-494	-884	23341
Tax on extraordinary profit or loss	36	42	0	-984	-1366
Other taxes	19973	-26974	-32209	-31421	-27406
Profit or loss for the financial year	7789302	3832611	6069348	9595936	2326769
Dividends (paid and proposed)	2055293	3076084	2748713	3466631	4051126
Profit or loss retained for the financial year	5734008	756527	3320635	6129305	-1724357

Table A1.1.3: Consolidated balance sheet of the UK non-life insurance industry (1985-1999)

	1985	1986	1987	1988	1989
ASSETS					
Property	1247769	1296319	1467543	1880426	2383781
Cash	2363712	3042042	3602212	4756353	5506581
Bonds	7289360	9445993	10552434	11379185	12339491
Equities & other shares	5474849	6815555	6948705	7675942	10288316
Affiliates	5316707	6699422	6196764	7254076	8945315
Insurance debts	4104828	4484715	4555188	5024915	5810047
Other assets	1483781	1580916	1983842	2143107	2874091
Prepayments & accrued income	656772	846542	1043746	1235458	1460953
Reinsurers' share of technical provisions	5292963	6059206	6615593	7339991	9659129
Total assets as per FSA/DTI returns	33230741	40270710	42966027	48689453	59267704
Reinsurers' share of technical provisions	5292963	6059206	6615593	7339991	9659129
Deferred acquisition costs	656772	846542	1043746	1235458	1460953
Adjusted total assets	27281006	33364962	35306688	40114004	48147622
LIABILITIES					
Provision for unearned premiums	2949797	3672454	4376803	5087142	5724135
Provision for claims outstanding	10596514	12723716	14177249	15705503	19089648
Provision for unexpired risks	118508	136067	157170	191471	241424
Other technical provisions	5755	78247	23418	87762	-22511
Net technical provisions	13670574	16610484	18734640	21071878	25032696
Other liabilities	3611027	4268272	4465293	5344485	6230972
Total liabilities	17281601	20878756	23199933	26416363	31263668
SHAREHOLDERS' FUNDS					
Capital	2236111	2478329	2808138	3166414	3779687
Extra shareholders' funds	69083	60744	31238	53327	58573
Other shareholders' funds	7693035	9927056	9244717	10477025	13044359
Shareholders' funds	9998229	12466129	12084093	13696766	16882619

Table A1.1.3: Consolidated balance sheet of the UK non-life insurance industry (1985-1999) (continued)

	1990	1991	1992	1993	1994
ASSETS					
Property	2163720	1895006	1550861	1591226	1346067
Cash	5642039	6210455	7306492	7767157	8307208
Bonds	11719225	13645824	17033589	22006926	21507770
Equities & other shares	8315190	8193799	7934245	10500739	10247282
Affiliates	7714181	8896630	10144996	12383418	9748733
Insurance debts	6686519	7337793	8187539	8263709	8184268
Other assets	3405826	3607052	4121301	4125111	4015370
Prepayments & accrued income	1619744	1813211	1922353	1982776	1985918
Reinsurers' share of technical provisions	11918175	13877145	18237785	18344563	18096639
Total assets as per FSA/DTI returns	59184619	65476915	76439161	86965625	83439255
Reinsurers' share of technical provisions	11918175	13877145	18237785	18344563	18096639
Deferred acquisition costs	1619744	1813211	1922353	1982776	1985918
Adjusted total assets	45646700	49786559	56279023	66638286	63356698
LIABILITIES					
Provision for unearned premiums	6187685	6739203	7634013	8453209	8568659
Provision for claims outstanding	21622714	25918813	28639136	30874156	31065228
Provision for unexpired risks	270026	364293	857552	638309	506463
Other technical provisions	-148043	-111181	-38941	-92913	-189122
Net technical provisions	27932382	32911128	37091760	39872761	39951228
Other liabilities	6328323	6649282	7008472	8124504	8870754
Total liabilities	34260705	39560410	44100232	47997265	48821982
SHAREHOLDERS' FUNDS					
Capital	4422870	5173514	6935283	8693076	9793810
Extra shareholders' funds	83948	78720	241535	195127	251190
Other shareholders' funds	6883512	4973868	4995248	9741446	4461045
Shareholders' funds	11390330	10226102	12172066	18629649	14506045

Table A1.1.3: Consolidated balance sheet of the UK non-life insurance industry (1985-1999) (continued)

	1995	1996	1997	1998	1999
ASSETS					
Property	1261020	1242181	1224610	825102	791088
Cash	8275074	10544807	9895186	9145421	7986245
Bonds	25432466	29177670	33665960	34175676	32993094
Equities & other shares	12584247	13135771	14995638	14651770	14463513
Affiliates	12616234	13702018	14330445	17440825	14515248
Insurance debts	10515875	16169391	13137501	12846699	13823374
Other assets	5129020	5966911	5596705	5202723	6026832
Prepayments & accrued income	3099047	3475738	3738879	3934682	4069744
Reinsurers' share of technical provisions	17065153	33702337	32497120	31100419	31629206
Total assets as per FSA/DTI returns	95978136	1.27E+08	1.29E+08	1.29E+08	1.26E+08
Reinsurers' share of technical provisions	17065153	33702337	32497120	31100419	31629206
Deferred acquisition costs	2320266	2599687	2822461	3058744	3234422
Adjusted total assets	76592717	90814800	93762463	95164154	91434716
LIABILITIES					
Provision for unearned premiums	8725957	9266290	9693101	9910266	10322118
Provision for claims outstanding	33539178	43216348	41666420	40759910	39704628
Provision for unexpired risks	709893	644800	610959	734527	724992
Other technical provisions	289677	124783	118344	150757	201216
Net technical provisions	43264705	53252221	52088824	51555461	50952952
Other liabilities	11347104	13089355	14379137	14428536	17128020
Total liabilities	54611809	66341576	66467961	65983997	68080972
SHAREHOLDERS' FUNDS					
Capital	10805420	12707612	13797568	17886201	16587492
Extra shareholders' funds	17853	318604	570879	595090	665812
Other shareholders' funds	11113040	11376603	12906118	10581543	5995253
Shareholders' funds	21936313	24402819	27274565	29062834	23248557

Table A1.1.4: Key ratios and measures of the UK non-life insurance industry (1985-1999)

Unit: %	1985	1986	1987	1988	1989
Real growth rate of GPW	N/A	15.12	1.23	3.65	4.40
Real growth rate of GDP	N/A	3.91	5.62	6.40	1.87
Solvency margin ratio	N/A	150.28	138.90	142.05	158.96
Bonds as % total assets	21.94	23.46	24.56	23.37	20.82
Reinsurers' share of technical provisions as % of total assets	15.93	15.05	15.40	15.08	16.30
Affiliates as % total assets	16.00	16.64	14.42	14.90	15.09
Equities & other shares as % total assets	16.48	16.92	16.17	15.77	17.36
Percentage change in shareholders' funds	N/A	24.68	-3.06	13.35	23.26
Return on shareholders' funds	N/A	9.33	9.79	17.96	13.69
Investment yield	N/A	5.20	4.90	5.27	5.98

Table A1.1.4: Key ratios and measures of the UK non-life insurance industry (1985-1999) (continued)

Unit: %	1990	1991	1992	1993	1994
Real growth rate of GPW	0.38	6.56	8.14	8.40	-3.33
Real growth rate of GDP	-0.98	-0.65	0.45	3.51	3.57
Solvency margin ratio	133.58	124.58	141.70	154.57	138.74
Bonds as % total assets	19.80	20.84	22.28	25.31	25.78
Reinsurers' share of technical provisions as % of total assets	20.14	21.19	23.86	21.09	21.69
Affiliates as % total assets	13.03	13.59	13.27	14.24	11.68
Equities & other shares as % total assets	14.05	12.51	10.38	12.07	12.28
Percentage change in shareholders' funds	-32.53	-10.22	19.03	53.05	-22.13
Return on shareholders' funds	-6.35	-26.32	-3.77	12.13	19.78
Investment yield	6.13	5.94	5.38	4.80	4.33

Table A1.1.4: Key ratios and measures of the UK non-life insurance industry (1985-1999) (continued)

Unit: %	1995	1996	1997	1998	1999
Real growth rate of GPW	1.22	19.33	-26.22	-7.73	2.94
Real growth rate of GDP	2.02	3.49	3.17	2.50	3.24
Solvency margin ratio	158.38	176.62	256.29	265.90	240.48
Bonds as % total assets	26.50	22.95	26.08	26.43	26.12
Reinsurers' share of technical provisions as % of total assets	17.78	26.51	25.18	24.05	25.04
Affiliates as % total assets	13.14	10.78	11.10	13.49	11.49
Equities & other shares as % total assets	13.11	10.33	11.62	11.33	11.45
Percentage change in shareholders' funds	51.22	11.24	11.77	6.56	-20.01
Return on shareholders' funds	25.75	20.74	15.37	16.92	11.84
Investment yield	5.79	4.59	5.13	4.98	4.09

A1.2 Life insurance industry

Table A1.2.1: Consolidated revenue account of the UK life insurance industry (1985-1999)

Unit: £000	1985	1986	1987	1988	1989
Earned premiums	16509135	20171566	23442593	24609216	33316032
Investment income receivable before tax	8238477	9189774	10018138	11668924	14220131
Change in the value of non-linked assets	1774150	2527718	3914532	4795875	7055063
Change in the value of linked assets	2260582	5485258	358892	2610083	10339769
Other income	1701708	1867814	1610888	1341325	3647326
Total income	30484052	39242130	39345043	16929133	68578321
Claims incurred	11145813	13829629	15920457	16929133	20134487
Expenses payable	3569914	4214064	4950118	6143489	7079737
Interest payable before tax	277933	276196	305480	333943	529825
Taxation	556419	683889	718869	607458	881324
Other expenditure	193185	983135	440754	701541	1159786
Transfer to (from) non technical account	322220	390403	469579	440800	607770
Total expenditure	16065484	20377316	22805257	25156393	30392929
Changes in funds	14418568	18864814	16539786	19869031	38185392
Funds brought forward	88465107	1.03E+08	1.22E+08	1.42E+08	1.61E+08
Funds carried forward	1.03E+08	1.22E+08	1.39E+08	1.61E+08	2E+08

Table A1.2.1: Consolidated revenue account of the UK life insurance industry (1985-1999) (continued)

Unit: £000	1990	1991	1992	1993	1994
Earned premiums	36464839	43061087	47191185	55680625	47191818
Investment income receivable before tax	16290482	17588055	18974511	19644720	21031196
Change in the value of non-linked assets	100869	7342578	7071755	19599588	-3658978
Change in the value of linked assets	-1.1E+07	5929317	7527964	21103465	-8223356
Other income	977536	7908448	2872170	5822508	3467598
Total income	43009663	81829485	83637587	1.22E+08	59808275
Claims incurred	22950659	26111711	30346251	34325887	34340273
Expenses payable	7732102	8629725	8940132	9299052	8972207
Interest payable before tax	663477	523564	476963	349402	402068
Taxation	649874	980870	1001354	1498201	1023029
Other expenditure	1142993	5104737	562798	4824943	1406870
Transfer to (from) non technical account	711876	834226	552523	909732	1164537
Total expenditure	33850982	42184834	41880022	51207217	47308985
Changes in funds	9158683	39644649	41757565	70643688	12499291
Funds brought forward	1.97E+08	2.06E+08	2.45E+08	2.86E+08	3.53E+08
Funds carried forward	2.07E+08	2.45E+08	2.87E+08	3.57E+08	3.66E+08

Table A1.2.1: Consolidated revenue account of the UK life insurance industry (1985-1999) (continued)

Unit: £000	1995	1996	1997	1998	1999
Earned premiums	47932870	56983791	65758628	79395984	96121862
Investment income receivable before tax	24795775	27940729	28845019	30781313	32328932
Change in the value of non-linked assets	11563146	9852778	30166497	43299944	10895575
Change in the value of linked assets	15139975	8839691	20011643	21499099	46329866
Other income	6746579	19160591	23925039	30740926	23765559
Total income	1.06E+08	1.23E+08	1.69E+08	2.06E+08	2.09E+08
Claims incurred	36188653	42872663	50235973	58183342	64677212
Expenses payable	8651247	9178891	9905264	10967994	12357319
Interest payable before tax	624151	735392	947711	1241373	1101677
Taxation	1804366	2292867	2903129	3226689	2582505
Other expenditure	853115	8966860	17058866	7767329	8359777
Transfer to (from) non technical account	1039619	482818	399946	312015	582945
Total expenditure	49161151	64529492	81450889	81698745	89661441
Changes in funds	57017196	58248086	87255938	1.24E+08	1.2E+08
Funds brought forward	3.61E+08	4.13E+08	4.69E+08	5.46E+08	6.69E+08
Funds carried forward	4.18E+08	4.71E+08	5.57E+08	6.7E+08	7.88E+08

Table A1.2.2: Consolidated profit and loss account of the UK life insurance industry (1985-1999)

Unit: £000	1985	1986	1987	1988	1989
Transfer from long term business revenue account	306407	378198	359436	397743	563487
Net investment income	703013	789761	850483	962864	1221215
Net re-adjustments on investments	0	0	0	0	0
Net realised gains	0	0	0	0	0
Net other income	-608503	-489477	-327420	31330	-437270
Pre-tax profit	400917	678482	882499	1391937	1347432
Tax on profit or loss	-3507	94013	155848	267346	183187
After-tax profit	404424	584469	726651	1124591	1164245
Extraordinary profit or loss	0	0	0	0	0
Tax on extraordinary profit or loss	0	0	0	0	0
Other taxes	0	0	0	0	0
Profit or loss for the financial year	404424	584469	726651	1124591	1164245
Dividends (paid and proposed)	421902	577070	649454	854359	955066
Profit or loss retained for the financial year	-17478	7399	77197	270232	209179

Table A1.2.2: Consolidated profit and loss account of the UK life insurance industry (1985-1999) (continued)

Unit: £000	1990	1991	1992	1993	1994
Transfer from long term business revenue account	669175	777473	332081	755917	1009706
Net investment income	1255299	1527546	1620607	1621749	1544300
Net re-adjustments on investments	0	0	0	0	0
Net realised gains	0	0	0	0	0
Net other income	-1877073	-2796630	-1372509	-703654	65201
Pre-tax profit	47401	-491611	580179	1674012	2619207
Tax on profit or loss	-138512	-359251	-105388	147305	392233
After-tax profit	185913	-132360	685567	1526707	2226975
Extraordinary profit or loss	0	0	0	0	0
Tax on extraordinary profit or loss	0	0	0	0	0
Other taxes	0	0	0	0	0
Profit or loss for the financial year	185913	-132360	685567	1526707	2226975
Dividends (paid and proposed)	1285983	1136488	1368479	1463999	1650445
Profit or loss retained for the financial year	-1100070	-1268848	-682912	62708	576530

Table A1.2.2: Consolidated profit and loss account of the UK life insurance industry (1985-1999) (continued)

Unit: £000	1995	1996	1997	1998	1999
Transfer from long term business revenue account	853798	408255	294781	209833	525565
Net investment income	1927043	1940327	2135893	1885744	1919886
Net re-adjustments on investments	1693213	262606	1908327	5549719	348668
Net realised gains	334616	405567	1523527	1452708	576858
Net other income	-66173	296390	-376902	-1054280	-1180270
Pre-tax profit	4742497	3313145	5485626	8043724	2190707
Tax on profit or loss	557909	347065	372770	366029	295528
After-tax profit	4184587	2966081	5112854	7677695	1895180
Extraordinary profit or loss	178	-855	-494	-884	1041
Tax on extraordinary profit or loss	37	25	0	0	-205
Other taxes	-353	-23785	-38801	-28580	-27973
Profit or loss for the financial year	4185081	2988986	5151161	7705391	1924399
Dividends (paid and proposed)	2022659	2506295	2874674	3119792	4164423
Profit or loss retained for the financial year	2162422	482691	2276487	4585599	-2240024

Table A1.2.3: Consolidated balance sheet of the UK life insurance industry (1985-1999)

Unit: £000	1985	1986	1987	1988	1989
ASSETS					
Property	16405842	18186252	22700100	28851474	33620673
Cash	2377628	2846269	4042335	5278747	6682165
Bonds	33888944	36435623	40015863	43839718	47541964
Equities & other shares	42819287	56106100	56871650	66243897	91312688
Affiliates	2277274	2557934	2446455	3137307	4266201
Insurance debts	740978	887448	938175	1262960	1408572
Other assets	7329627	8548617	10090482	11609735	13728259
Prepayments & accrued income	0	0	0	0	0
Reinsurers' share of technical provisions	0	0	0	0	0
Assets held to cover linked liabilities	31369649	41506189	46785600	52688257	68936346
Total assets as per FSA/DTI returns	1.37E+08	167074432	1.84E+08	2.13E+08	2.67E+08
Reinsurers' share of technical provisions	0	0	0	0	0
Deferred acquisition costs	0	0	0	0	0
Adjusted total assets	1.37E+08	167074432	1.84E+08	2.13E+08	2.67E+08
LONG TERM LIABILITIES AND MARGINS					
Mathematical reserves after surplus distribution	1.02E+08	120738617	1.37E+08	1.6E+08	1.98E+08
Balance of surplus	1041828	1262377	1260312	1673771	1938958
Long term business fund	1.03E+08	122000994	1.39E+08	1.61E+08	2E+08
Claims outstanding- gross	0	0	0	0	0
Claims outstanding- reinsurers' share	0	0	0	0	0
Claims outstanding- net	0	0	0	0	0
Provisions for other risks and charges	0	0	0	0	0
Deposits received from reinsurers	0	0	0	0	0
Creditors & liabilities	6555378	8378342	9540131	9856974	11634354
Accruals & deferred income	0	0	0	0	0
Provision for adverse changes	0	0	0	0	0
Total other insurance & non-insurance liabilities	6555378	8378342	9540131	9856974	11634354
Excess of the value of net admissible assets	27771521	36695486	35842625	41670739	56329711
Total liabilities and margins	1.37E+08	167074822	1.84E+08	2.13E+08	2.67E+08
SHAREHOLDERS' FUNDS					
Capital	1259771	1359538	1488913	1727369	1989319
Extra shareholders' funds	15391	18663	15736	42604	47933
Other shareholders' funds	4095788	5255846	4798659	5294201	6765552
Shareholders' funds	5370950	6634047	6303308	7064174	8802804

Table A1.2.3: Consolidated balance sheet of the UK life insurance industry (1985-1999) (continued)

Unit: £000	1990	1991	1992	1993	1994
ASSETS					
Property	30357489	27778562	25594892	27833039	30276836
Cash	9859944	9570884	10952765	9757267	8686088
Bonds	47394053	59196429	78540960	1.03E+08	94879397
Equities & other shares	79543872	98182232	1.13E+08	1.49E+08	1.44E+08
Affiliates	4389562	5429419	5733839	6673946	6733505
Insurance debts	1551385	1341811	1406362	1383598	1452843
Other assets	14454971	15240167	15440932	15435549	14173221
Prepayments & accrued income	0	0	0	0	14
Reinsurers' share of technical provisions	0	0	0	0	0
Assets held to cover linked liabilities	63406162	76833219	91734699	1.25E+08	1.26E+08
Total assets as per FSA/DTI returns	2.51E+08	2.94E+08	3.43E+08	4.39E+08	4.26E+08
Reinsurers' share of technical provisions	0	0	0	0	0
Deferred acquisition costs	0	0	0	0	0
Adjusted total assets	2.51E+08	2.94E+08	3.43E+08	4.39E+08	4.26E+08
LONG TERM LIABILITIES AND MARGINS					
Mathematical reserves after surplus distribution	2.05E+08	2.44E+08	2.85E+08	3.55E+08	3.64E+08
Balance of surplus	1628712	1885314	1868245	2050889	2248361
Long term business fund	2.07E+08	2.45E+08	2.87E+08	3.57E+08	3.66E+08
Claims outstanding- gross	0	0	0	0	0
Claims outstanding- reinsurers' share	0	0	0	0	0
Claims outstanding- net	0	0	0	0	0
Provisions for other risks and charges	0	0	0	0	0
Deposits received from reinsurers	0	0	0	0	0
Creditors & liabilities	11331037	11656863	11500485	14733803	14923467
Accruals & deferred income	0	0	0	0	0
Provision for adverse changes	0	0	0	0	0
Total other insurance & non-insurance liabilities	11331037	11656863	11500485	14733803	14923467
Excess of the value of net admissible assets	33084022	36415738	44127356	67305715	45173085
Total liabilities and margins	2.51E+08	2.94E+08	3.43E+08	4.39E+08	4.26E+08
SHAREHOLDERS' FUNDS					
Capital	2317958	2897863	4956599	5304566	6092377
Extra shareholders' funds	69160	71346	74438	188250	239000
Other shareholders' funds	3713800	3008434	2723267	5730274	2847770
Shareholders' funds	6100918	5977643	7754304	11223090	9179147

Table A1.2.3: Consolidated balance sheet of the UK life insurance industry (1985-1999) (continued)

Unit: £000	1995	1996	1997	1998	1999
ASSETS					
Property	29169578	29973894	33155721	37002866	41210442
Cash	12223955	15133901	18662660	19974789	17521501
Bonds	1.09E+08	1.2E+08	1.39E+08	1.73E+08	1.8E+08
Equities & other shares	1.7E+08	1.94E+08	2.31E+08	2.49E+08	3.03E+08
Affiliates	8966505	8749472	8892928	10372588	12119126
Insurance debts	1579537	1629102	1706688	2168037	2187146
Other assets	11608814	10323745	10544760	11347278	11345782
Prepayments & accrued income	3354172	3536802	3838709	4297415	4232388
Reinsurers' share of technical provisions	2851	522	318	112	0
Assets held to cover linked liabilities	1.52E+08	1.77E+08	2.15E+08	2.72E+08	3.59E+08
Total assets as per FSA/DTI returns	4.98E+08	5.59E+08	6.62E+08	7.8E+08	9.31E+08
Reinsurers' share of technical provisions	2851	522	318	112	0
Deferred acquisition costs	0	0	2	0	0
Adjusted total assets	4.98E+08	5.59E+08	6.62E+08	7.8E+08	9.31E+08
LONG TERM LIABILITIES AND MARGINS					
Mathematical reserves after surplus distribution	4.16E+08	4.67E+08	5.52E+08	6.65E+08	7.82E+08
Balance of surplus	2499335	3892850	4976061	5157577	6096668
Long term business fund	4.18E+08	4.71E+08	5.57E+08	6.7E+08	7.88E+08
Claims outstanding- gross	565	852979	1434305	1696415	2113254
Claims outstanding- reinsurers' share	0	32541	79251	89688	188031
Claims outstanding- net	565	820438	1355055	1606726	1925222
Provisions for other risks and charges	1309	2534689	3528120	4042892	5624359
Deposits received from reinsurers	2616318	2479185	2318289	2280672	2884869
Creditors & liabilities	13251034	13145037	14954148	17003240	18216572
Accruals & deferred income	591618	698090	843078	981854	1043573
Provision for adverse changes	9514	4849	7686	3091	46966
Total other insurance & non-insurance liabilities	16470358	19682288	23006376	25918475	29741561
Excess of the value of net admissible assets	63448947	68774415	82711528	83995814	1.13E+08
Total liabilities and margins	4.98E+08	5.59E+08	6.62E+08	7.8E+08	9.31E+08
SHAREHOLDERS' FUNDS					
Capital	7907837	7985379	9630999	13511282	13915164
Extra shareholders' funds	979	107822	224981	192756	245399
Other shareholders' funds	5870116	5823138	6866259	6042324	2781508
Shareholders' funds	13778932	13916339	16722239	19746362	16942071

Table A1.2.4: Key ratios and measures of the UK life insurance industry (1985-1999)

Unit: %	1985	1986	1987	1988	1989
Real growth rate of GPE	N/A	18.69	12.65	-2.07	26.60
Real growth rate of GDP	N/A	3.91	5.62	6.40	1.87
Free asset ratio	N/A	18.55	16.17	16.16	17.73
Equities & other shares as % total assets	31.21	33.58	30.93	31.11	34.14
Assets held to match linked liabilities as % total assets	22.86	24.84	25.44	24.75	25.77
Bonds as % total assets	24.70	21.81	21.76	20.59	17.77
Percentage change in shareholders' funds	N/A	23.52	-4.99	12.07	24.61
Return on shareholders' funds	N/A	11.30	13.64	20.83	16.98
Investment yield	N/A	6.04	5.71	5.88	5.92

Table A1.2.4: Key ratios and measures of the UK life insurance industry (1985-1999) (continued)

Unit: %	1990	1991	1992	1993	1994
Real growth rate of GPE	2.40	9.65	11.15	18.09	-14.32
Real growth rate of GDP	-0.98	-0.65	0.45	3.51	3.57
Free asset ratio	10.36	9.72	10.00	12.37	8.34
Equities & other shares as % total assets	31.70	33.44	33.09	33.99	33.79
Assets held to match linked liabilities as % total assets	25.27	26.17	26.76	28.55	29.59
Bonds as % total assets	18.89	20.16	22.91	23.58	22.26
Percentage change in shareholders' funds	-30.69	-2.02	29.72	44.73	-18.21
Return on shareholders' funds	0.64	-8.14	8.45	17.64	25.68
Investment yield	6.28	6.46	5.96	5.03	4.86

Table A1.2.4: Key ratios and measures of the UK life insurance industry (1985-1999) (continued)

Unit: %	1995	1996	1997	1998	1999
Real growth rate of GPE	-8.08	14.06	14.35	22.80	18.43
Real growth rate of GDP	2.02	3.49	3.17	2.50	3.24
Free asset ratio	10.66	10.36	10.07	8.24	10.02
Equities & other shares as % total assets	34.09	34.61	34.95	31.93	32.59
Assets held to match linked liabilities as % total assets	30.59	31.59	32.49	34.92	38.60
Bonds as % total assets	21.89	21.40	20.97	22.23	19.29
Percentage change in shareholders' funds	50.11	1.00	20.16	18.08	-14.20
Return on shareholders' funds	41.31	23.93	35.81	44.11	11.94
Investment yield	5.36	5.29	4.72	4.27	3.78

Appendix A2: Definitions of accounts in consolidated financial statements and of key ratios

The following tables in this appendix defines the accounts in the three consolidate financial statements and the key ratios discussed in Chapter three. The notations used in these tables are explained as follows.

F: Form of the FSA/DTI returns

C: Column in the Form

L: Line in the Form

Besides, in order to further simplify the notations the sign of colon (:) is used as a range operator, which produces one reference to all the lines between two references, including the two references. For instance, *F21,C1,L11:L15* means the sum of the values of Lines 11, 12, 13, 14 and 15 in Column 1 of Form 21.

It should be noted that the all the Forms of the FSA/DTI returns listed below are exactly the same as the Forms prescribed in the Insurance Companies (Accounts and Statements) Regulations 1996, except Form 14 consisting the accounts of long term business liabilities and margins. The Form 14 in Table A2.2.3 is referred to as the Form in the data set of SynThesys Life.

A2.1 Non-life insurance industry

Table A2.1.1: Definitions of accounts in technical account of the UK non-life insurance industry

Account	Definition
Gross premiums written	(F21,C1,L11:L15+F21,C2,L12:L15)+F24,C99-99,L11
Reinsurance ceded	Gross premiums written - Net premiums written
Net premiums written	(F21,C5,L11:L15+F21,C6,L12:L15)+F24,C99-99,L19
Increase in premiums reserve	Net premiums written – Net premiums earned
Net premiums earned	F20,L11+F20,L21+F24,C99-99,L19
Net claims incurred	F20,L12+F20,L22+F24,C99-99,L29
Claims management costs	F20,L13+F20,L23+F24,C99-99,L39
Commissions	F22,C4,L21+F24,C99-99,L41
Other acquisition expenses	F22,C4,L22+F24,C99-99,L42
Administrative expenses	F22,C4,L23+F24,C99-99,L43
Reinsurers commissions & profit participations	F22,C4,L24+F24,C99-99,L44
Net operating expenses	F20, L13+F20,L23+F24,C99-99,L39+ F22,C4,L21:23 + F24,C99-99,L41:43– F22,C4,L24–F24,C99-99,L44
Adjustments for discounting	F20,L14+F20,L24
Change in technical provisions	F24,C99-99,L59
Increase in provision for unexpired risks	F20,L15
Other technical income or charges	F20,L16+F20,L25
Underwriting profit	Net premiums earned−Net claims incurred−Net operating expenses+Adjustments for discounting −Change in technical provisions−Increase in provision for unexpired risks+Other technical income

Table A2.1.2: Definitions of accounts in non-technical account of the UK non-life insurance industry

Account	Definition
Underwriting profit	Net premiums earned−Net claims incurred−Net operating expenses+Adjustments for discounting −Change in technical provisions−Increase in provision for unexpired risks+Other technical Income
Net investment income	F16,L14–F16,L17
Net realised gains	F16,L16–F16,L19
Other income	F16,L21+F16,L13
Pre-tax profit	Sum of the 4 items above
Tax on profit or loss	F16,L31
After-tax profit	F16,L39
Extraordinary profit or loss	F16,L41
Tax on extraordinary profit or loss	F16,L42
Other taxes	F16,L43
Profit or loss for the financial year	F16,L49
Dividends (paid and proposed)	F16,L51
Profit or loss retained for the financial year	F16,L59

Table A2.1.3: Definitions of accounts in balance sheet of the UK non-life insurance industry

Account	Definition
ASSETS	
Property	F13,L11
Cash	F13,L54+F13,L55+F13,L81+F13,L82
Bonds	F13,L45+F13,L46+F13,L47+F13,L48
Equities & other shares	F13,L41+F13,L42+F13,L43+F13,L49
Affiliates	F13,L21:L30
Insurance debts	F13,L57+F13,L71+F13,L72+F13,L74+F13,L75
Other assets	F13,L44+F13,L50+F13,L51+F13,L52+F13,L53+ F13,L56+F13,L73+F13,L76+F13,L77+F13,L78+ F13,L79+F13,L80+F13,L83
Prepayments & accrued income	F13,L84+F13,L85+F13,L86
Reinsurers' share of technical provisions	F13,L60+F13,L61+F13,L62+F13,L63
Total assets as per FSA/DTI returns	Sum of the asset items above
Reinsurers' share of technical provisions	F13,L60+F13,L61+F13,L62+F13,L63
Deferred acquisition costs	F13,L85
Adjusted total assets	Total assets as per FSA/DTI returns minus above 2 items
LIABILITIES	
Provision for unearned premiums	F15,L11–F13,L60–F13,L85
Provision for claims outstanding	F15,L12–F13,L61
Provision for unexpired risks	F15,L13–F13,L62
Other technical provisions	F15,L16–F13,L63
Net technical provisions	F15,L19–L13,L60–F13,L61–F13,L62–F13,L63– F13,L85–F15,L14–F15,L15
Other liabilities	F15,L21+F15,L22+F15,L31+F15,L41+F15,L42+ F15,L43+F15,L44+F15,L45+F15,L46+F15,L47+ F15,L48+F15,L49+F15,L51
Total liabilities	Net technical provisions + Other liabilities
SHAREHOLDERS' FUNDS	
Capital	F10,L51
Extra shareholders' funds	F15,L14+F15,L15
Other shareholders' funds	F10,L56
Shareholders' funds	Sum of above 3 items

A2.2 Life insurance industry

Table A2.2.1: Definitions of accounts in long term business revenue account of the UK life insurance industry

Account	Definition
Earned premiums	F40, L11
Investment income receivable before tax	F40, L12
Change in the value of non-linked assets	F40, L13
Change in the value of linked assets	F40, L14
Other income	F40, L15
Total income	F40, L11:L15
Claims incurred	F40, L21
Expenses payable	F40, L22
Interest payable before tax	F40, L23
Taxation	F40, L24
Other expenditure	F40, L25
Transfer to (from) non technical account	F40, L26
Total expenditure	F40, L21:L26
Changes in funds	F40, L11:L15– F40, L21:L26
Funds brought forward	F40, L49
Funds carried forward	F40, L59

Table A2.2.2: Definitions of accounts in profit and loss account of the UK life insurance industry

Account	Definition
Transfer from long term business revenue account	F16, L13
Net investment income	F16, L14–F16, L17
Net re-adjustments on investments	F16, L15–F16, L18
Net realised gains	F16, L16–F16, L19
Net other income	F16, L21+ F16, L11+ F16, L12–F16, L20
Pre-tax profit	Sum of above 5 items
Tax on profit or loss	F16, L31
After-tax profit	F16, L39
Extraordinary profit or loss	F16, L41
Tax on extraordinary profit or loss	F16, L42
Other taxes	F16, L43
Profit or loss for the financial year	F16, L49
Dividends (paid and proposed)	F16, L51
Profit or loss retained for the financial year	F16, L59

Table A2.2.3: Definitions of accounts in balance sheet of the UK life insurance industry

Account	Definition
LONG TERM BUSINESS ASSETS	
Property	F13,L11
Cash	F13,L54+F13,L55+F13,L81+F13,L82
Bonds	F13,L45+F13,L46+F13,L47+F13,L48
Equities & other shares	F13,L41+F13,L42+F13,L43+F13,L49
Affiliates	F13,L21:L30
Insurance debts	F13,L57+F13,L71+F13,L72+F13,L74+F13,L75
Other assets	F13,L44+F13,L50+F13,L51+F13,L52+F13,L53+ F13,L56+F13,L73+F13,L76+F13,L77+F13,L78+ F13,L79+F13,L80+F13,L83
Prepayments & accrued income	F13,L84+F13,L85+F13,L86
Reinsurers' share of technical provisions	F13,L60+F13,L61+F13,L62+F13,L63
Assets held to cover linked liabilities	F13,L58+ F13,L59
Total assets as per FSA/DTI returns	Sum of the asset items above
Reinsurers' share of technical provisions	F13,L60+F13,L61+F13,L62+F13,L63
Deferred acquisition costs	F13,L85
Adjusted total assets	Total assets as per FSA/DTI returns minus above 2 items
LONG TERM BUSINESS LIABILITIES AND MARGINS	
Mathematical reserves after surplus distribution	F14, L11
Balance of surplus	F14, L13
Long term business fund	F14, L14
Claims outstanding- gross	F14, L15
Claims outstanding- reinsurers' share	F14, L16
Claims outstanding- net	F14, L17
Provisions for other risks and charges	F14, L21+ F14, L22
Deposits received from reinsurers	F14, L23
Creditors & liabilities	F14, L31:L38
Accruals & deferred income	F14, L39
Provision for adverse changes	F14, L41
Total other insurance & non-insurance liabilities	F14, L17: F14, L41
Excess of the value of net admissible assets	F14, L51
Total liabilities and margins	F14, L59
SHAREHOLDERS' FUNDS	
Capital	F10,L51
Extra shareholders' funds	F15,L14+F15,L15
Other shareholders' funds	F10,L56
Shareholders' funds	Sum of the above 3 items

Appendix B: Postal Questionnaires and Correspondences

[First covering letter sent to Chief Actuaries in the non-life survey]

Yung-Ming Shiu
Doctoral Student
School of Management
The University of Edinburgh
William Robertson Building
50 George Square
Edinburgh EH8 9JY

<<Recipient's name>>
<<Position>>
<<Company>>
<<Address 1>>
<<Address 2>>
<<City>>
<<Post Code>>

Date:

Dear **[Recipient]**:

I am a doctoral student in the School of Management at the University of Edinburgh. For my Ph.D. thesis, I am investigating the current practices of dynamic financial analysis in the U.K. insurance companies carrying on general business under the joint supervision of Dr. Peter Moles and Dr. Andy Adams.

As part of my research, I am undertaking a survey of the use of dynamic financial analysis techniques by insurance companies. I would be grateful if you could spare a little of your time to complete the enclosed questionnaire by ticking the boxes which most accurately describe your company. If you consider a question is not applicable to your company, please indicate this in the space provided or simply leave that question blank. Please complete and return this questionnaire even if your company does not use any dynamic financial analysis related techniques.

Once completed, please return the questionnaire in the reply-paid envelope as soon as possible, preferably not later than **[preferred return date]**. Alternatively, you may fax the questionnaire to me on (0131) 668-3053. If you have any queries concerning the questionnaire, please contact me by fax on (0131) 668-3053 or by email at yung-ming.shiu@ed.ac.uk Dr. Peter Moles can be contacted by phone on (0131) 650-3795 or by email at p.moles@ed.ac.uk

Please rest assured that all responses will be treated in the strictest confidentiality. If you wish to have an analytical report of my findings and conclusions, please indicate this on your reply and enclose a business card or compliment slip so that we may send you a copy of the analysis.

Thank you very much for your co-operation.

Yours sincerely,

Yung-Ming Shiu

Private and Confidential

School of Management
The University of Edinburgh

Dynamic Financial Analysis and Financial Condition Report Questionnaire:

The purpose of the questionnaire below is to assist in a study of the current practices of dynamic financial analysis and financial condition report in U.K. insurance companies carrying on general business. Individuals will not be identified within the study but responses will be grouped with other data in the analysis.

Part A: Dynamic Financial Analysis

1. Does your company use any of the following dynamic financial analysis (DFA) related techniques? [Please tick all the boxes that apply.]

Sensitivity testing	Scenario testing	Stochastic simulation	None of the above
☐	☐	☐	☐

☛ **If you have answered "none of the above", please proceed to Part A, Question 13 on page 4. Otherwise, please continue to Part A, Question 2.**

---

2. What are the applications of the DFA related techniques in your company? [Please tick all the boxes that apply.]

Solvency testing	☐	Asset allocation	☐
Capital allocation	☐	Surplus allocation	☐
Evaluate reinsurance programmes	☐	Evaluate merger and acquisition	☐
Help develop business plan	☐	Communicate the results with rating agencies	☐
Pricing	☐	Other (please specify in box below)	☐

---

3. If your company uses scenario testing, how many scenarios does your company run regularly? [Please tick one.]

1 ~10	**11~20**	**21~30**	**31~40**	**41 ~ 50**	**51-60**	**Other (Please specify in box below)**
☐	☐	☐	☐	☐	☐	☐

---

4. If your company uses scenario testing, how often does your company normally do scenario tests? [Please tick one.]

Daily	Weekly	Monthly	Quarterly	Half yearly	Annually	Other (Please specify in box below)
☐	☐	☐	☐	☐	☐	☐

5. If your company uses scenario testing, has your company included any of the following risk categories in the scenarios, i.e. has your company tested variations in the following assumptions? [Please tick one box for each risk category or assumption.]

Risk category	Yes	No	Not applicable
a) Future investment conditions	☐	☐	☐
b) Levels of new business	☐	☐	☐
c) Expenses	☐	☐	☐
e) Taxation	☐	☐	☐
f) Effects of asset-defaults	☐	☐	☐
g) Risk of reinsurer default	☐	☐	☐
h) Frequency and severity	☐	☐	☐
i) Pricing	☐	☐	☐
j) Misestimation of policy liabilities	☐	☐	☐
k) Deterioration of asset values	☐	☐	☐
l) Government and political action	☐	☐	☐
m) Off balance sheet (e.g. derivatives)	☐	☐	☐
n) Unexpected inflation	☐	☐	☐
o) Interest rate level	☐	☐	☐
p) Equity returns	☐	☐	☐
q) Premium volume	☐	☐	☐
r) Leverage	☐	☐	☐
t) Liquidity	☐	☐	☐
u) Asset mix	☐	☐	☐
Other (please specify in box below)	☐	☐	☐

6. How important to the performance of your company are the following factors? [Please tick the box on the following scale which most adequately reflects the importance of each factor to the performance of your company.]

	Least important 1	2	3	4	Most important 5
a) Unexpected inflation	☐	☐	☐	☐	☐
b) Interest rate change	☐	☐	☐	☐	☐
c) Interest rate level	☐	☐	☐	☐	☐
d) Equity returns	☐	☐	☐	☐	☐
e) Company size	☐	☐	☐	☐	☐
f) Reinsurance dependence	☐	☐	☐	☐	☐
g) Leverage	☐	☐	☐	☐	☐
h) Solvency margin	☐	☐	☐	☐	☐
i) Stability of underwriting operation	☐	☐	☐	☐	☐
j) Liquidity	☐	☐	☐	☐	☐
k) Stability of asset structure	☐	☐	☐	☐	☐
Other (please specify in box below)	☐	☐	☐	☐	☐

7. Has your company modelled any of the following economic variables and in what way? [Please tick one box for each economic variable.]

Economic variable	No	Yes: Deterministic	Yes: Stochastic
Term structure of Interest rates	☐	☐	☐
Inflation	☐	☐	☐
Equity returns	☐	☐	☐
Currency rates	☐	☐	☐
Credit spreads	☐	☐	☐
Other (please specify in box below)	☐	☐	☐

8. What are the capabilities of asset modelling in your company [Please tick all the boxes that apply.]

Assumptions can be varied from year to year	☐	Can project the total investment return	☐
Can vary income and gains independently	☐	Separate model points for different asset classes	☐
Individual assets can be modelled	☐	Other (please specify in box below)	☐

9. What does your company normally use to model the liabilities? [Please tick all the boxes that apply.]

All in force policies individually	☐	All in force policies in aggregate	☐
Most in force policies individually	☐	Most in force policies in aggregate	☐
A sample of in force policies individually	☐	A sample of in force policies in aggregate	☐
Model points	☐	Other (please specify in box below)	☐

10. How long are your company's forecast periods in DFA and in business plan (BP) respectively? [Please tick one box for DFA and BP respectively.]

	1 year	2 years	3 years	4 years	5 years	6 ~ 10 years	11 ~ 15 years	16 ~ 20 years	> 20 years
DFA	☐	☐	☐	☐	☐	☐	☐	☐	☐
BP	☐	☐	☐	☐	☐	☐	☐	☐	☐

11. Are the DFA results incorporated in the decision making process by senior management in your company? [Please tick the box which most accurately describes your company on the following scale]

Always	Usually	Often	Occasionally	Never
☐	☐	☐	☐	☐

12. Which of the following difficulties has been experienced in communicating the DFA results to the Board of Directors? [Please tick all the boxes that apply.]

Lack of interest	☐	Concern regarding the degree of conservatism in selecting adverse scenarios	☐
Difficulties in communicating complex issues to non-specialists	☐	Too much focus on assumptions rather than results	☐
How to present extremely adverse scenarios without causing undue concern	☐	Other (please specify in box below)	☐

13. What are the main reasons for not using the DFA related techniques? [Please tick all the boxes that apply.]

Lack of need	☐	Too expensive	☐
Lack of relevant knowledge	☐	Lack of appropriate asset or liability models	☐
Lack of experience	☐	Other (please specify in box below)	☐

Part B: Financial Condition Report

1. Does your company produce financial condition report or its equivalent? [Please tick one.]

No ☐ **Yes** ☐ →

How often does your company produce financial condition report?

Annually ☐

Other (please specify): ________

If you have answered "no", please proceed to Part B, Question 4 on page 5. Otherwise, please continue to Part B, Question 2.

2. Is the financial condition report or its equivalent of your company available to the following third parties? [Please tick one for each party.]

	No	Yes
Auditors of your company	☐	☐
The Financial Services Authority (The FSA)	☐	☐

→ Should the FSA have automatic access to the financial condition report?

No ☐

Yes ☐

3. Is it necessary to introduce a Guidance Note on financial condition report specifically for insurance companies carrying on general business? [Please tick one]

No ☐ **Yes** ☐ →

What classification would you like the Guidance Note to be? [Please tick one]

Initially advisory ☐

Initially practice standard ☐

Mandatory ☐

4. What are the main reasons for not producing financial condition report or its equivalent? [Please tick all the boxes that apply.]

Lack of need	☐	Lack of guidance	☐
Lack of relevant knowledge	☐	Too expensive	☐
Lack of experience	☐	Other (please specify in box below)	☐

Part C: The Characteristics of your Company

What insurance contracts does your company sell? [Please tick all the boxes that apply.]

Accident & health	☐	Motor	☐
Marine, aviation and transport	☐	Property	☐
Liability	☐	Miscellaneous & Pecuniary loss	☐
Other (please specify in box below)	☐		

Please add any further comments you may have

Thank you very much for your help in this research. Please attach your business card if you wish to receive a summary of the results.

Tick here if you are willing to be interviewed as part of this research. ☐

Please return the questionnaire in the pre-paid envelope to:

Yung-Ming Shiu
Doctoral Student
School of Management
The University of Edinburgh
William Robertson Building
50 George Square
EDINBURGH EH8 9JY

Or fax your completed questionnaire to (0131) 668-3053

[Follow-up letter sent to non-respondents in the non-life survey]

Yung-Ming Shiu
Doctoral Student
School of Management
The University of Edinburgh
William Robertson Building
50 George Square
Edinburgh EH8 9JY

<<Recipient's name>>
<<Position>>
<<Company>>
<<Address 1>>
<<Address 2>>
<<City>>
<<Post Code>>

Date:

Dear **[Recipient]**:

Recently I wrote to you requesting your assistance in completing a questionnaire for my doctoral research investigating the current practices of dynamic financial analysis and financial condition reporting in the U.K. insurance companies carrying on general business.

At the time of writing, I have not received a completed questionnaire from you. If your reply has crossed this letter in the post, please disregard this letter. If you have not already done so, I would be grateful if you could spare a little of your time to complete the enclosed questionnaire by ticking the boxes which most accurately describe your company. If you consider a question is not applicable to your company, please indicate this in the space provided or simply leave that question blank. Please complete and return this questionnaire even if your company does not use any dynamic financial analysis related techniques or produce any financial condition reports.

Once completed, please return the questionnaire in the reply-paid envelope as soon as possible. Alternatively, you may fax the questionnaire to me on (0131) 668-3053. If you have any queries concerning the questionnaire, please contact me by fax on (0131) 668-3053 or by email at yung-ming.shiu@ed.ac.uk My principal supervisor, Dr. Peter Moles, can be contacted by phone on (0131) 650-3795 or by email at p.moles@ed.ac.uk

Please rest assured that all responses will be treated in the strictest confidentiality. If you wish to have an analytical report of my findings and conclusions, please indicate this on your reply and enclose a business card or compliment slip so that we may send you a copy of the analysis.

Thank you very much for your co-operation.

Yours sincerely,

Yung-Ming Shiu

[Follow-up email sent to non-respondents in the non-life survey]

From: Yung-Ming Shiu <yungming@wrb1.bae.ed.ac.uk>
To: **Recipient's email address**
Subject: **Dynamic Financial Analysis & Financial Condition Report**
Date sent: **[Date and time]**

Dear **[Recipient]**,

Dynamic Financial Analysis & Financial Condition Report

I refer to the above, and to the questionnaire which I forwarded to you twice. To date I have not received your response, and I understand that this may be due to the normal pressures of business.

However, I would be very grateful if you could forward a response as soon as possible in order that I may progress the research analysis.

If you would like a third copy of the questionnaire please do not hesitate to contact me. May I take this opportunity to thank you for your contribution to my research.

Yours sincerely

Yung-Ming Shiu

Doctoral Student
School of Management
The University of Edinburgh

[First covering letter sent to Appointed Actuaries in the life survey]

Yung-Ming Shiu
Doctoral Student
School of Management
The University of Edinburgh
William Robertson Building
50 George Square
Edinburgh EH8 9JY

<<Recipient's name>>
<<Position>>
<<Company>>
<<Address 1>>
<<Address 2>>
<<City>>
<<Post Code>>

Date

Dear [**Recipient**]:

I am a doctoral student in the School of Management at the University of Edinburgh. For my Ph.D. thesis, I am investigating the current practices of dynamic solvency testing in the U.K. insurance companies and friendly societies carrying on long-term business under the joint supervision of Dr. Peter Moles and Dr. Andy Adams.

As part of my research, I am undertaking a survey of the use of dynamic solvency testing techniques by insurance companies and friendly societies. I would be grateful if you could spare a little of your time to complete the enclosed questionnaire by ticking the boxes which most accurately describe your company. If you consider a question is not applicable to your company, please indicate this in the space provided or simply leave that question blank. Please complete and return this questionnaire even if your company does not use any dynamic solvency testing related techniques.

Once completed, please return the questionnaire in the reply-paid envelope as soon as possible, preferably not later than [**preferred return date**]. Alternatively, you may fax the questionnaire to me on (0131) 668-3053. If you have any queries concerning the questionnaire, please contact me by fax on (0131) 668-3053 or by email at yung-ming.shiu@ed.ac.uk Dr. Peter Moles can be contacted by phone on (0131) 650-3795 or by email at p.moles@ed.ac.uk

Please rest assured that all responses will be treated in the strictest confidentiality. If you wish to have an analytical report of my findings and conclusions, please indicate this on your reply and enclose a business card or compliment slip so that we may send you a copy of the analysis.

Thank you very much for your co-operation.

Yours sincerely,

Yung-Ming Shiu

Private and Confidential

School of Management
The University of Edinburgh

Dynamic Solvency Testing and Financial Condition Report Questionnaire:

The purpose of the questionnaire below is to assist in a study of the current practices of dynamic solvency testing and financial condition report in U.K. insurance companies and friendly societies carrying on long-term business. Individuals will not be identified within the study but responses will be grouped with other data in the analysis.

Part A: Dynamic Solvency Testing

1. Does your company use any of the following dynamic solvency testing (DST) related techniques? [Please tick all the boxes that apply.]

Sensitivity testing	Scenario testing	Stochastic simulation	None of the above
☐	☐	☐	☐

☛ If you have answered "none of the above", please proceed to Part A, Question 13 on page 5. Otherwise, please continue to Part A, Question 2.

---

2. What are the applications of the DST related techniques in your company? [Please tick all the boxes that apply.]

Solvency testing	☐	Asset allocation	☐
Capital allocation	☐	Surplus allocation	☐
Evaluate reinsurance programmes	☐	Evaluate merger and acquisition	☐
Help develop business plan	☐	Communicate the results with rating agencies	☐
Pricing	☐	Other (please specify in box below)	☐

---

3. If your company uses scenario testing, how many scenarios does your company run regularly? [Please tick one.]

1 ~10	11~20	21~30	31~40	41 ~ 50	51-60	Other (Please specify in box below)
☐	☐	☐	☐	☐	☐	☐

---

4. If your company uses scenario testing, how often does your company normally do scenario tests? [Please tick one.]

Daily	Weekly	Monthly	Quarterly	Half yearly	Annually	Other (Please specify in box below)
☐	☐	☐	☐	☐	☐	☐

5. If your company uses scenario testing, has your company included any of the following risk categories in the scenarios, i.e. has your company tested variations in the following assumptions? [Please tick one box for each risk category or assumption.]

Risk category	Yes	No	Not applicable
a) Future investment conditions	☐	☐	☐
b) Levels of new business	☐	☐	☐
c) Expenses	☐	☐	☐
e) Persistency	☐	☐	☐
f) Allocation of profit	☐	☐	☐
g) Mortality and morbidity	☐	☐	☐
h) Taxation	☐	☐	☐
i) Exercising of options by policyholders	☐	☐	☐
j) Exercising of options by the company	☐	☐	☐
k) Effects of asset-defaults	☐	☐	☐
l) Unit pricing bases	☐	☐	☐
m) Risk of reinsurer default	☐	☐	☐
n) Cash flow mismatch	☐	☐	☐
o) Deterioration of asset values	☐	☐	☐
p) Government and political action	☐	☐	☐
q) Off balance sheet (e.g. derivatives)	☐	☐	☐
r) Unexpected inflation	☐	☐	☐
t) Interest rate level	☐	☐	☐
u) Equity returns	☐	☐	☐
v) Premium volume	☐	☐	☐
w) Leverage	☐	☐	☐
x) Liquidity	☐	☐	☐
y) Asset mix	☐	☐	☐
z) Bonus rate	☐	☐	☐
Other (please specify in box below)	☐	☐	☐

6. How important to the performance of your company are the following factors? [Please tick the box on the following scale which most adequately reflects the importance of each factor to the performance of your company.]

	Least important 1	2	3	4	Most important 5
a) Unexpected inflation	☐	☐	☐	☐	☐
b) Interest rate change	☐	☐	☐	☐	☐
c) Interest rate level	☐	☐	☐	☐	☐
d) Equity returns	☐	☐	☐	☐	☐
e) Company size	☐	☐	☐	☐	☐
f) Reinsurance dependence	☐	☐	☐	☐	☐
g) Assets held to cover linked liabilities as % of total assets	☐	☐	☐	☐	☐
h) Leverage	☐	☐	☐	☐	☐
i) Free asset ratio	☐	☐	☐	☐	☐
j) Stability of underwriting operation	☐	☐	☐	☐	☐
k) Liquidity	☐	☐	☐	☐	☐
l) Stability of asset structure	☐	☐	☐	☐	☐
m) Life & general annuity reserves as % of total reserves	☐	☐	☐	☐	☐
n) Pension reserves as % of total reserves	☐	☐	☐	☐	☐
o) Permanent health reserves as % of total reserves	☐	☐	☐	☐	☐
Other (please specify in box below)	☐	☐	☐	☐	☐

7. Has your company modelled any of the following economic variables and in what way? [Please tick one box for each economic variable.]

Economic variable	No	Yes	
		Deterministic	Stochastic
Term structure of Interest rates	☐	☐	☐
Inflation	☐	☐	☐
Equity returns	☐	☐	☐
Currency rates	☐	☐	☐
Credit spreads	☐	☐	☐
Other (please specify in box below)	☐	☐	☐

8. What are the capabilities of asset modelling in your company [Please tick all the boxes that apply.]

Assumptions can be varied from year to year	☐	Can project the total investment return	☐
Can vary income and gains independently	☐	Separate model points for different asset classes	☐
Individual assets can be modelled	☐	Other (please specify in box below)	☐

9. What does your company normally use to model the liabilities? [Please tick all the boxes that apply.]

All in force policies	☐	Most in force policies	☐
A sample of in force policies	☐	Other (please specify in box below)	☐
Model points	☐		

→ How many model points does your company use: _______

10. How long are your company's forecast periods in DST and in business plan (BP) respectively? [Please tick one box for DST and BP respectively.]

	1 year	2 years	3 years	4 years	5 years	6 ~ 10 years	11 ~ 15 years	16 ~ 20 years	> 20 years
DST	☐	☐	☐	☐	☐	☐	☐	☐	☐
BP	☐	☐	☐	☐	☐	☐	☐	☐	☐

11. Are the DST results incorporated in the decision making process by senior management in your company? [Please tick the box which most accurately describes your company on the following scale]

Always	**Usually**	**Often**	**Occasionally**	**Never**
☐	☐	☐	☐	☐

12. Which of the following difficulties has been experienced in communicating the DST results to the Board of Directors? [Please tick all the boxes that apply.]

Lack of interest	☐	Concern regarding the degree of conservatism in selecting adverse scenarios	☐
Difficulties in communicating complex issues to non-specialists	☐	Too much focus on assumptions rather than results	☐
How to present extremely adverse scenarios without causing undue concern	☐	Other (please specify in box below)	☐

13. What are the main reasons for not using the DST related techniques? [Please tick all the boxes that apply.]

Lack of need	☐	Too expensive	☐
Lack of relevant knowledge	☐	Lack of appropriate asset or liability models	☐
Lack of experience	☐	Other (please specify in box below)	☐

Part B: Financial Condition Report

1. Does your company produce financial condition report or its equivalent? [Please tick one.]

No ☐ Yes ☐

How often does your company produce financial condition report?

Annually ☐

Other (please specify): ________

If you have answered "no", please proceed to Part B, Question 4 on page 6. Otherwise, please continue to Part B, Question 2.

2. Is the financial condition report or its equivalent of your company available to the following third parties? [Please tick one for each party.]

	No	Yes
Auditors of your company	☐	☐
The Financial Services Authority (The FSA)	☐	☐

Should the FSA have automatic access to the financial condition report?

No ☐

Yes ☐

3. To what extent is the Guidance Note 2: Financial condition reports issued by the Faculty and Institute of Actuaries acceptable? [Please tick one]

Least acceptable 1	2	3	4	Most acceptable 5
☐	☐	☐	☐	☐

If you have ticked "1" or "2" in the above question, please specify in box below the most important reason for the Guidance Note 2 being unacceptable.

4. What are the main reasons for not producing financial condition report or its equivalent? [Please tick all the boxes that apply.]

Lack of need	☐	Lack of guidance	☐
Lack of relevant knowledge	☐	Too expensive	☐
Lack of experience	☐	Other (please specify in box below)	☐

Part C: The Characteristics of your Company

What insurance contracts does your company sell? [Please tick all the boxes that apply.]

Non-linked contracts (other than with-profit policies)	☐	Property linked contracts	☐
Accumulating with-profit policies	☐	Index linked contracts	☐
Other (please specify in box below)	☐		

Please add any further comments you may have

Thank you very much for your help in this research. Please attach your business card if you wish to receive a summary of the results.

Tick here if you are willing to be interviewed as part of this research. ☐

Please return the questionnaire in the pre-paid envelope to:

Yung-Ming Shiu
Doctoral Student
School of Management
The University of Edinburgh
William Robertson Building
50 George Square
EDINBURGH EH8 9JY

Or fax your completed questionnaire to (0131) 668-3053

[Follow-up letter sent to non-respondents in the life survey]

Yung-Ming Shiu
Doctoral Student
School of Management
The University of Edinburgh
William Robertson Building
50 George Square
Edinburgh EH8 9JY

<<Recipient's name>>
<<Position>>
<<Company>>
<<Address 1>>
<<Address 2>>
<<City>>
<<Post Code>>

Date:

Dear **[Recipient]**:

Recently I wrote to you requesting your assistance in completing a questionnaire for my doctoral research investigating the current practices of dynamic solvency testing and financial condition reporting in the U.K. insurance companies and friendly societies carrying on long-term business.

At the time of writing, I have not received a completed questionnaire from you. If your reply has crossed this letter in the post, please disregard this letter. If you have not already done so, I would be grateful if you could spare a little of your time to complete the enclosed questionnaire by ticking the boxes which most accurately describe your company. If you consider a question is not applicable to your company, please indicate this in the space provided or simply leave that question blank. Please complete and return this questionnaire even if your company does not use any dynamic solvency testing related techniques or produce any financial condition reports.

Once completed, please return the questionnaire in the reply-paid envelope as soon as possible. Alternatively, you may fax the questionnaire to me on (0131) 668-3053. If you have any queries concerning the questionnaire, please contact me by fax on (0131) 668-3053 or by email at yung-ming.shiu@ed.ac.uk My principal supervisor, Dr. Peter Moles, can be contacted by phone on (0131) 650-3795 or by email at p.moles@ed.ac.uk

Please rest assured that all responses will be treated in the strictest confidentiality. If you wish to have an analytical report of my findings and conclusions, please indicate this on your reply and enclose a business card or compliment slip so that we may send you a copy of the analysis.

Thank you very much for your co-operation.

Yours sincerely,

Yung-Ming Shiu

[Follow-up email sent to non-respondents in the life survey]

From: Yung-Ming Shiu <yungming@wrb1.bae.ed.ac.uk>
To: **Recipient's email address**
Subject: **Dynamic Solvency Testing & Financial Condition Report**
Date sent: **[Date and time]**

Dear **[Recipient]**,

Dynamic Solvency Testing & Financial Condition Report

I refer to the above, and to the questionnaire which I forwarded to you twice. To date I have not received your response, and I understand that this may be due to the normal pressures of business.

However, I would be very grateful if you could forward a response as soon as possible in order that I may progress the research analysis.

If you would like a third copy of the questionnaire please do not hesitate to contact me. May I take this opportunity to thank you for your contribution to my research.

Yours sincerely

Yung-Ming Shiu

Doctoral Student
School of Management
The University of Edinburgh

Appendix C: Interview Instruments, Correspondences and Transcripts

[Covering letter sent to non-life respondents for possible interview arrangement]

Yung-Ming Shiu
Doctoral Student
School of Management
The University of Edinburgh
William Robertson Building
50 George Square
Edinburgh EH8 9JY

<<Recipient's name>>
<<Position>>
<<Company>>
<<Address 1>>
<<Address 2>>
<<City>>
<<Post Code>>

Date:

Dear **[Recipient]**:

Thank you very much for kindly participating in the survey regarding dynamic financial analysis and financial condition report that I have distributed as part of my doctoral research at Edinburgh University. Your contribution to my research is highly appreciated.

My research focuses on the current practices of dynamic financial analysis and financial condition reporting in insurance companies. To be more specific, I would like to investigate how insurance companies use dynamic financial analysis techniques to investigate their risk profile and how they prepare their financial condition reports. I feel that my understanding of this topic would benefit greatly from a discussion with you about these current practices in your company.

I will be visiting **[Place]** on **[a period of time]** and I was wondering if you would be available to meet with me at this time. I have enclosed a summary of the topics that I would like to discuss with you. This should take approximately 30-40 minutes. Please rest assured that all information you give me will be treated in the strictest confidentiality and the name of your company will not be identified in my research report.

I will contact you by telephone on **[Date]** and, should you agree to participate, I will arrange a suitable time for my visit. In the meantime, should you have any queries concerning this interview, please contact me by email at yung-ming.shiu@ed.ac.uk
May I thank you again for your valuable contribution to my research and co-operation. I look forward to meeting with you.

Yours sincerely,

Yung-Ming Shiu

[Topics for discussion at the interview with organisations using DFA and FCR]

School of Management
The University of Edinburgh

Dynamic Financial Analysis and Financial Condition Reporting: Topics for Discussion

1. The Risk Profile of your Company

Insurance companies are risk intermediaries and as a result face not only general business risks that are common to other ordinary businesses but those risks which are specific to insurance.

1.1 What are the main insurance risks your company faces?

1.2 In what way does your company investigate its risk profile, i.e. how does your company identify the material risks affecting company performance?

2. The Use of Dynamic Financial Analysis (DFA) Techniques in your Company

Sensitivity testing, scenario testing and stochastic simulation (modelling) are three main DFA techniques used to assess the solvency position of an insurance company.

2.1 To what extent is your company able to use such techniques for solvency testing or any other purposes?

2.2 How does your company establish which risk factors should be tested?

2.3 To what extent is your company able to allow for interactions between assets, liabilities and other factors?

2.4 Have the results of DFA investigations ever directly led your company to take any material measure in underwriting or investment operations? If yes, please give an example.

2.5 What factors limit the ability of your company to use DFA techniques? (for example, the practical difficulties in applying DFA techniques.)

2.6 What features of the DFA techniques does your company plan to improve in the next one to three years?

3. Financial Condition Reporting in your Company

3.1 What do you include in your company's financial condition report?

3.2 To what extent do you think whether it is necessary to introduce a Guidance Note on financial condition report specifically for insurance companies carrying on general business?

3.3 To what extent do you think whether a financial condition report is a worthwhile exercise?

3.4 Does your company plan to improve financial condition report in the next one to three years? If yes, what will be the key features of the report?

[Topics for discussion at the interview with organisations using DFA, but not FCR]

School of Management
The University of Edinburgh

Dynamic Financial Analysis and Financial Condition Reporting: Topics for Discussion

1. The Risk Profile of your Company

Insurance companies are risk intermediaries and as a result face not only general business risks that are common to other ordinary businesses but those risks which are specific to insurance.

1.1 What are the main insurance risks your company faces?

1.2 In what way does your company investigate its risk profile, i.e. how does your company identify the material risks affecting company performance?

2. The Use of Dynamic Financial Analysis (DFA) Techniques in your Company

Sensitivity testing, scenario testing and stochastic simulation (modelling) are three main DFA techniques used to assess the solvency position of an insurance company.

2.1 To what extent is your company able to use such techniques for solvency testing or any other purposes?

2.2 How does your company establish which risk factors should be tested?

2.3 To what extent is your company able to allow for interactions between assets, liabilities and other factors?

2.4 Have the results of DFA investigations ever directly led your company to take any material measure in underwriting or investment operations? If yes, please give an example.

2.5 What factors limit the ability of your company to use DFA techniques? (for example, the practical difficulties in applying DFA techniques.)

2.6 What features of the DFA techniques does your company plan to improve in the next one to three years?

3. Financial Condition Reporting in your Company

3.1 What are the reasons for not producing financial condition report or its equivalent?

3.2 To what extent do you think whether it is necessary to introduce a Guidance Note on financial condition report specifically for insurance companies carrying on general business?

3.3 To what extent do you think whether a financial condition report is a worthwhile exercise?

3.4 Does your company plan to produce financial condition report in the next one to three years? If yes, what will be the key features of the report?

[Covering letter sent to life respondents for possible interview arrangement]

Yung-Ming Shiu
Doctoral Student
School of Management
The University of Edinburgh
William Robertson Building
50 George Square
Edinburgh EH8 9JY

<<Recipient's name>>
<<Position>>
<<Company>>
<<Address 1>>
<<Address 2>>
<<City>>
<<Post Code>>

Date:

Dear **[Recipient]**:

Thank you very much for kindly participating in the survey regarding dynamic solvency testing and financial condition report that I have distributed as part of my doctoral research at Edinburgh University. Your contribution to my research is highly appreciated. The research is now moving into a second phase during which I hope to conduct more detailed interviews. In the returned questionnaire, you indicated that you are willing to be interviewed as part of this research. I would like to take up this opportunity.

My research focuses on the current practices of dynamic solvency testing and financial condition reporting in insurance companies. To be more specific, I would like to investigate how insurance companies use dynamic solvency testing techniques to investigate their risk profile and how they prepare their financial condition reports. I feel that my understanding of this topic would benefit greatly from a discussion with you about these current practices in your company.

I will be visiting **[Place]** on **[a period of time]** and I was wondering if you would be available to meet with me at this time. I have enclosed a summary of the topics that I would like to discuss with you. This should take approximately 30-40 minutes. Please rest assured that all information you give me will be treated in the strictest confidentiality and the name of your company will not be identified in my research report.

Whilst I am aware that demands on your time are considerable I would be most appreciative if you would agree to see me. I will contact you by telephone within the next few days to obtain your response and hopefully to agree an interview date. In the meantime, should you have any queries concerning this interview, please contact me by email at yung-ming.shiu@ed.ac.uk May I thank you again for your valuable contribution to my research and co-operation. I look forward to meeting with you.

Yours sincerely,

Yung-Ming Shiu

[Topics for discussion at the interview with organisations using DST and FCR]

School of Management
The University of Edinburgh

Dynamic Solvency Testing and Financial Condition Reporting: Topics for Discussion

1. The Risk Profile of your Company

Insurance companies are risk intermediaries and as a result face not only general business risks that are common to other ordinary businesses but those risks which are specific to insurance.

1.1 What are the main insurance risks your company faces?
1.2 In what way does your company investigate its risk profile, i.e. how does your company identify the material risks affecting company performance?

2. The Use of Dynamic Solvency Testing (DST) Techniques in your Company

According to GN2: Financial Condition Reports issued by the Faculty and Institute of Actuaries, sensitivity testing, scenario testing and stochastic simulation (modelling) are the three main techniques used to assess the solvency position of an insurance company.

2.1 To what extent is your company able to use such techniques for solvency testing or any other purposes?
2.2 How does your company establish which risk factors should be tested?
2.3 To what extent is your company able to allow for interactions between assets, liabilities and other factors?
2.4 Have the results of DST investigations ever directly led your company to take any material measure in underwriting or investment operations? If yes, please give an example.
2.5 What factors limit the ability of your company to use DST techniques? (for example, the practical difficulties in applying DST techniques.)
2.6 To what extent does your company comply with GN2?
2.7 What features of the DST techniques does your company plan to improve in the next one to three years?

3. Financial Condition Reporting in your Company

3.1 What do you include in your company's financial condition report?
3.2 In what way do you feel that the GN2 could be improved?
3.3 To what extent do you think whether a financial condition report is a worthwhile exercise?
3.4 What additional features in the financial condition report do you expect to add in the next one to three years?

Transcript of Interview with Statutory Reporting & Pricing Manager of Insurance Company A held on 12 July 2002

Interviewer: What are the main risks your organisation faces?

Interviewee: Probably the most significant risk is investment market risk without any doubt. What happened in the last 10 to 20 years is that the main business written by life offices has shifted away from traditional risk protection mortality business towards investment related business. And in particular with-profits type business where you have underlying investment guarantees. The investment risk is the major risk that our company and the other vast majority of life offices face at the moment. This highlights it more than ever by what we are seeing the current investment market. So typically there are substantial equities attached to some type business. Equities and guarantees do not go hand to hand. That presents significant risk to every office.

Mortality risk presents fairly significant degree of risk for pension offices like ourselves predominantly through guaranteed annuities that have been offered twenty years ago. Mortality risk itself is not such a big deal for the risk business we write because we can change the rate we charge on most modern risk contracts on a year-to-year basis. Thus, mortality risk is not such a big issue apart from guaranteed annuity business.

Definitely investment risk is the key one. Falling equity market and falling interest rates present us with difficulties.

Interviewer: How does your company identify material risks affecting company performance?

Interviewee: The ways of identifying the key risks such as investment risk are very obvious. It is not too difficult to focus on these at the moment. However, other types of risks such as operational risk and business risk are a bit more difficult to quantify and measure.

In addition, there will some regulatory changes in the near future. For example, from 2004 the FSA is going to change the framework of regulating the insurance industry. We are moving towards risk capital based approach. We do not know what it means for sure at the moment. The risks such as operational risk and business risk will be focused in the future regulation. There are quite a bit detailed work to be done to satisfy the regulator.

Interviewer: Does your company use Dynamic Solvency Testing (DST) to identify the risks?

Interviewee: The DST that we are carrying out is very much focused on the changes in investment market. One of the important issues regarding DST is that how you actually go about modelling. How do you model operational risk and management action, and so on? This is a great difficulty that companies face. That is relatively straightforward to model investment market, but it is harder to model operational risk and management action. I am not convinced that anybody has really yet come up with suitable means to model management action.

Interviewer: Does your company use Wilkie investment model?

Interviewee: Yes. We have used a combination of Wilkie model that we developed internally and other stochastic investment models developed by some consultants in Edinburgh. You get very different results depending on what investment model you use. That is a great challenge going forward in trying to audit the results from these models.

Interviewer: In the questionnaire, you indicated that your company only applies stochastic simulation to certain business lines. Why is that?

Interviewee: That is probably a fairly common position at the moment. I cannot imagine that any company is able to apply stochastic techniques to its complete in-force book of business. We have done a lot of stochastic work on single premium investment bond and with-profits pension business on model point basis. For example, how much should you charge for cost of capital to with-profits with guarantees? How should that be reflected in return to policyholders? We need to better understand the cost of the guarantees we are offering. That's why we are focusing on these contracts.

Interviewer: How many model points does your company use?

Interviewee: About 50 for the modelling work we have done.

Interviewer: What does your company do in financial condition report and the DST techniques you use?

Interviewee: The projections are deterministic. The projection period is five years. We make appropriate assumptions about new business volume, decrements and mortality rate, etc. We effectively project out the in-force book of business to the next five years. At the same time, we make appropriate assumptions about the way we will invest and the cash flows we will receive. At each year-end, we will have book business of in-force and book of assets. We then will carry out valuations of assets and liabilities at that point of time. We run a large number of such projections. We can vary a number of assumptions such as new business volume, etc. That gives us some pretty useful information. For example, could we continue to write large volume of with-profits business with guarantees?

We carry out the projections at the end of each calendar year. We would like to know the solvency position of the company. What happens if there are immediate moves in interest rates in conjunction with the moves in equity market? We will conduct a number of sensitivity tests such as changes in interest rates, say, plus and minus 200 basis points, and changes in equity market, say, plus and minus 5%. That gives us some idea about what changes in investment markets we are exposed to.

Besides, writing new business in the UK is very capital intensive because of substantial up-front cost such as commissions and initial expenses. Capital is required to support new business. Our company's capital is provided by our shareholders. So the projections in the FCR give us an indication of the likely level of capital that our shareholders are required to put in to sustain new business group.

Interviewer: To what extent is your company able to use these techniques for solvency testing?

Interviewee: At the moment, the solvency testing is very much deterministic. We are rapidly developing stochastic techniques. I do not think anybody quite know how they will be used within the risk based framework. We definitely need to develop our understanding on that very quickly.

Interviewer: How does your company establish which risk factors should be tested?

Interviewee: Establishing risk factors is very straightforward because it is very obvious. Mainly based on professional judgement. That is the tricky bit.

Interviewer: To what extent is your company able to allow for interactions between assets, liabilities and other factors?

Interviewee: Liabilities are driven by the assets effectively because of discount rates. You discount on the market rates of interest. That is the UK framework which requires you to do. The liabilities depend on the assets. So there is full interactions.

Interviewer: Have the results of DST investigations ever directly led your company to take any material measure in underwriting or investment operations?

Interviewee: Yes, they have. Along with other major with-profits offices, the results of solvency projections are very important. Can we continue to write new business on certain terms? The key thing that our DST has brought out is that: can we afford to maintain the equity content we are currently offering for with-profits business. We have made some changes to the equity content of with-profits business. This directly results from DST results. There have been some really important decisions we have taken as a result of these projections in DST.

Interviewer: Is there any factors which limit the ability of your company to use DST techniques?

Interviewee: Technology and data are two biggest factors. We would like to carry out stochastic simulation of our business. But, trying to capture all the relevant data is an absolutely colossal task. Even we could capture the data, to try and run simulation for a million policies, for example, will take us forever. That is a big problem. That is why we only do model points at this moment.

Interviewer: To what extent does your company comply with GN2?

Interviewee: I think we fully comply with GN2 and GN2 should be made mandatory. We fully support the use of FCR.

Interviewer: What features of the DST techniques does your company plan to improve in the next one to three years?

Interviewee: Stochastic simulation will be the main thing. There will be some improvements required to the deterministic projections and sensitivity testing.

Interviewer: What do you include in your company's financial condition report?

Interviewee: There are deterministic projections, deterministic sensitivities, projections showing capital requirement in order to sustain the new business volume, analysis of movement in the statutory solvency position over the year, some commentary on the results of our embedded value work, decrement analysis, detailed commentary on what happened to the solvency position over last year, commentary on new business strategies and new business volume, and commentary from the point of actuaries on policyholders' reasonable expectations, etc. It is a substantial work.

Interviewer: In what way do you feel that the GN2 could be improved?

Interviewee: It's difficult to answer. I think at the moment it depends to a large degree on how the ability to develop stochastic work is. If a company was in a position where they could use stochastic techniques at low cost, then some requirements to do that would be welcomed. I think there are some large difficulties associated with doing it. I think we are quite comfortable with GN2.

Interviewer: Do you think whether a financial condition report is a worthwhile exercise?

Interviewee: Definitely. For example, had Equitable Life produced the FCR and carried out insurance solvency projections and sensitivities, you would like to think that they would never have found themselves in the position that they ultimately ended up happening. That is a classic example why FCR should be made mandatory.

Interviewer: What additional features in the financial condition report do you expect to add in the next one to three years?

Interviewee: This would development of stochastic work. Trying to give information on cost of capital associated with in-force new business lines and hopefully extending simulation, a bit more than just model points.

Transcript of Interview with Appointed Actuary of Insurance Company B held on 16 July 2002

Interviewer: What are the main risks your organisation faces?

Interviewee: As you might be aware, our company is closed to new business. So we do not face any particular expense risk or risk with respect to new business. Because our business is unit-linked and we have good matching of assets and liabilities, apart form the fact we have a lot of guaranteed annuities options and linked business, the main risk we face are interest rate risk (interest rates fall) and mortality risk (mortality improves). And on annuity book, the main risk is, again, mortality risk (mortality improves). There are other risks such as lapse risk and so on, but they tend not to affect the solvency of the company. They just make lower profit and they are not real risks as such.

We did have some quite major operational risks. We have lots of mortgage portfolios. They are also some legal risks. If a legal case against us, it could cost us a lot of money.

Interviewer: How does your company identify material risks affecting company performance?

Interviewee: The company largely relies on myself, as an Appointed Actuary to identify these risks. There are other devices such as risk people who also look at things. But these major things tend to be done to me or to actuaries as a whole to identify or quantify if possible.

Interviewer: To what extent is your company able to use these techniques for solvency testing?

Interviewee: For our company, we can certainly do sensitivity testing of the main things we have talked about. We have got some limited scenario testing capability, but not as much as I like. We have not done any stochastic simulation. But for annuity guarantees, we have lots of external people who are quite happy to do a number for us, because they want to make money. If we need it (stochastic simulation), we got it.

Interviewer: What kind of scenarios does your company use?

Interviewee: In terms of scenarios, we simply look at things like falls in equity market in terms of future profit, not solvency risk. And elapse risk as well. Annuity mortality is a more sensitivity testing.

Interviewer: How does your company establish which risk factors should be tested?

Interviewee: Largely based on professional judgement.

Interviewer: To what extent is your company able to allow for interactions between assets, liabilities and other factors?

Interviewee: No real need to do it, because it is a non-profit linked office. We are not writing with-profits business. I think we can allow the extent we have to, but that is very limited.

Interviewer: Have the results of DST investigations ever directly led your company to take any material measure in underwriting or investment operations?

Interviewee: No, never.

Interviewer: Is there any factors which limit the ability of your company to use DST techniques?

Interviewee: I would say yes. The difficulty in writing models and the cost for doing so are the practical difficulties. As I said, external people have done a number for us for free.

Interviewer: Does your company use Wilkie investment model?

Interviewee: No, we do not. We do not need it anyway. It is not a good model for our purpose. For our company, a quite simple model would be sufficient because we do not have with-profits business. We only need a more complicate model for annuity guarantees. As I said, we got some external work done on that.

Interviewer: To what extent does your company comply with GN2?

Interviewee: As a non-profit office, I think we comply with GN2 to the extent we need to. GN2 is only advisory. It does say that actuaries should do whatever is appropriate for their offices. Some parts of the GN2 such as investment are irrelevant to our company. So we do not do it.

Interviewer: What features of the DST techniques does your company plan to improve in the next one to three years?

Interviewee: We will have to develop stochastic modelling because of the new FSA's requirements about guaranteed annuity business. Definitely stochastic modelling will be improved.

Interviewer: What do you include in your company's financial condition report?

Interviewee: Basically, the major risks which we identified and the possible impact of these risks on the business.

Interviewer: In what way do you feel that the GN2 could be improved?

Interviewee: I think GN2 should be completely thrown out. GN2 is very much geared to with-profits offices and to specific problems about assets and liabilities. To be honest, there is nothing in it which I find any useful whatever would tell me or make me do anything different. My conclusion is that it should be thrown out and actuaries use their judgement to do whatever is appropriate to their offices. The FSA are going to require the kind of modelling which the GN2 suggested. Therefore, I do not see any point in keeping GN2.

Interviewer: Do you think whether a financial condition report is a worthwhile exercise?

Interviewee: I think it is a worthwhile exercise and it is appropriate for the office.

Interviewer: What additional features in the financial condition report do you expect to add in the next one to three years?

Interviewee: I suspect we will be including some stochastic work on guarantee annuity options in the near future.

Transcript of Interview with Actuarial Manager of Insurance Company C held on 16 July 2002

Interviewer: What are the main types of insurance contracts your company sells?

Interviewee: Unit-linked contracts, pension and life, and major annuity business. We also sell some with-profits business, but we reinsure to xxxx insurance company.

Interviewer: What are the main risks your organisation faces?

Interviewee: For annuity business, the main risk is longevity (mortality) risk. Unit-linked side, it would be expense and lapse risks.

Interviewer: In what way does your company investigate its risk profile?

Interviewee: We investigate company risk profile by doing expense analysis, mortality analysis, lapse analysis. We analyse the experience, looking into the past. We do some runs of embedded value on different sets of assumptions, but not very many.

Interviewer: To what extent is your company able to use these techniques for solvency testing? How long is your company's forecast period in DST?

Interviewee: We do some sensitivity testing, but not very much. We change the sales and volumes. This year we will do FCR on investment return. This will be sensitivity testing, because we will change on variable at a time. However, we have not really looked at scenario testing. We use a five-year projection period.

Interviewer: Why does your company not do scenario testing?

Interviewee: Probably lack of resources to do it. What we are thinking of the main assumptions are investment returns and lapses. We change investment, sales, and inflation individually. We keep them separate. We have not done stochastic simulation because we do not have an appropriate model. But we are in the process of building stochastic modelling capability.

Interviewer: How does your company establish which risk factors should be tested?

Interviewee: Given the unit-linked contracts, we do expense analysis and lapse analysis. Largely based on professional judgement.

Interviewer: To what extent is your company able to allow for interactions between assets, liabilities and other factors?

Interviewee: No, we do not have a unified model. So we cannot. Because our main business is unit-linked contracts, it is not very important.

Interviewer: Have the results of DST investigations ever directly led your company to take any material measure in underwriting or investment operations?

Interviewee: No, not really.

Interviewer: Is there any factors which limit the ability of your company to use DST techniques?

Interviewee: Yes. People and IT.

Interviewer: To what extent does your company comply with GN2?

Interviewee: We do FCR and sensitivity testing only. If GN2 becomes mandatory, we will have no problems with fully complying with it.

Interviewer: Do you think whether GN2 should be made mandatory?

Interviewee: Yes or No. I think actuaries should do it no matter it is mandatory or not. I think it is a shame if they have to be told to do it.

Interviewer: What features of the DST techniques does your company plan to improve in the next one to three years?

Interviewee: I think it is stochastic modelling and building up how we produce model points. And also we would like to get feedback by comparing what the actual results with the results obtained from stochastic modelling.

Interviewer: Will your company plan to do scenario testing in the future?

Interviewee: Not significantly. As I said, we look at sensitivity testing about investment returns and inflation. There are sort of scenarios there. I don't think we will do anything bigger than that.

Interviewer: What do you include in your company's financial condition report?

Interviewee: We include basic projections, the main risks, taxes, investment, stock market crashes, compliance issues, mortality, reinsurance, insolvency.

Interviewer: In what way do you feel that the GN2 could be improved?

Interviewee: I do not know. I never thought about it. I have no opinion on that matter.

Interviewer: Do you think whether a financial condition report is a worthwhile exercise?

Interviewee: I think it is very important. Projecting the capital position of the company under different situations is very important.

Interviewer: What additional features in the financial condition report do you expect to add in the next one to three years?

Interviewee: This company will merge with another company at the end of the year. So this will be driven by people in London. I think there will be more and more paper work to be done.

Transcript of Interview with Pricing Actuary of Insurance Company D held on 17 July 2002

Interviewer: What are the main risks your organisation faces?

Interviewee: Premium risk, reserving risk, credit risk, asset risk, investment risk, and operational risk.

Interviewer: In what way does your company investigate its risk profile?

Interviewee: We do several things. The first thing on the risk side is that we manage our aggregate risk exposure. The system we used to enter each risk also indicates to us the profile of that risk, whether it domiciles in the US, Japan or elsewhere in the world. What is the limit? Or what is our share of that exposure? Any point in time we can actually analyse the report from our system to see what our mean exposures are? That is how we manage catastrophic exposure, for example. We have a specific team of four people. They manage catastrophic exposure of the company.

Interviewer: To what extent is your company able to use these techniques for solvency testing or any other purposes?

Interviewee: The usage of DFA is quite general. If we look at the stochastic model we have, we only use it for pricing. For example, we use the model to evaluate reinsurance programmes. For example, we can change the limit and excess point on our model to see how much this reinsurance is going to cost us. And what is the most efficient way to buy reinsurance? We also start to use scenario analysis for our reinsurance. We would like to have a model with all our business in it, so we can use it to evaluate different strategies.

Interviewer: How does your company establish which risk factors should be tested? What kind of assumptions does your company vary?

Interviewee: Because we use our model for pricing, there are two variables we vary. These are claim severity and claim frequency. We treat these two elements as random variables in our analysis. By varying these two variables, we would obtain mean ultimate lost cost and the variability around that loss cost. From that, we would work out what the risk premium should be. Then we obviously have profit margin and target loss ratio. Then we would quote the premium based on the profit margin we want to get.

Interviewer: To what extent is your company able to allow for interactions between assets, liabilities and other factors?

Interviewee: Because our business is volatile, we generally take on a very short-term investment strategy. We do not actually model our assets versus liabilities to come up with any investment strategies. However, we look at the profile of our liabilities and we make sure that our assets to some extent match the liabilities. We do not have a model which combines both assets and liabilities together.

Interviewer: Does your company use Wilkie investment model?

Interviewee: No, we don't. General speaking, Wilkie investment model is for long-term use. Our business is short-term. That's why we do not use Wilkie investment model.

Interviewer: Does your company use any particular commercial software or system to do DFA?

Interviewee: No, we do not. We use only EXCEL and @RISK.

Interviewer: Have the results of DFA investigations ever directly led your company to take any material measure in underwriting or investment operations?

Interviewee: Yes. On many occasions, the results of our pricing model would suggest us we do not write this contract. After discussing with our underwriter, we might decide not to write the contract.

Interviewer: Is there any factors which limit the ability of your company to use DFA techniques?

Interviewee: I think it is company culture. In our company, the history of actuarial involvement is very short, about four or five years. Our department has been only in place only for one year. It's the culture of the organisation that we try to change. Try to show that we can work with the underwriters to improve the understanding of the risks. I am sure it is just a matter of time before we go down this route to build some kind of DFA models. And I certainly know that at the moment what we are doing is that we putting together working parties within our organisation to look at different options to see how best to build or buy a DFA model. The final decision is up to senior management. They have to see the value of DFA models. The reason why we are not there today is probably because of culture of the organisation.

Interviewer: What features of the DFA techniques does your company plan to improve in the next one to three years?

Interviewee: Stochastic modelling.

Interviewer: What do you include in your company's financial condition report?

Interviewee: The main risks we are facing, some results of DFA, commentary on past performance, etc.

Interviewer: To what extent do you think whether it is necessary to introduce a Guidance Note on financial condition report specifically for insurance companies carrying on general business?

Interviewee: I think the FSA is doing that. If you look at the new "N2" requirement, from 2003 the FSA will require the Director of the company to sign on the FCR or something very similar, which shows the risks within the organisation. It looks like the only way to do that is through DFA models. So you can demonstrate that you clearly understand the risks of your business. And you have to show in the report that you are monitoring them. This report needs to be signed by the Director. I think this regulation is coming. I would say that it is necessary to introduce a Guidance Note for non-life insurance companies.

Interviewer: Do you think whether this Guidance Note should be made mandatory or advisory only?

Interviewee: Either one is OK. If you make it mandatory, maybe small companies cannot cope with it. If you have something out there, the companies who think it is important will go down that route to show the investor and clients that we are prepared to go down this route because we have nothing to hide. So I think it is a good thing.

Interviewer: To what extent do you think whether a financial condition report is a worthwhile exercise?

Interviewee: I think it is good for your clients because they can see your financial strength. It is good for potential and existing shareholders too. It is helpful to use the report to communicate with rating agencies such as S&P. So I think it is a worthwhile exercise.

Interviewer: Does your company plan to improve financial condition report in the next one to three years?

Interviewee: I think we have to. Commercially we will be forced to. The FSA is introducing new regulations. I know Lloyd's has requirements for reporting. And in fact some of the requirements of Lloyd's are even greater than the company's requirements. For example, Lloyd's actuaries have to sign on the solvency opinion on the reserves. Because our company is listed on the NYSE and is part of S&P 500, in order to demonstrate to all the third parties that we are confident about our financial position. So we will definitely do something within next one year.

Transcript of Interview with Chief Actuary of Insurance Company E held on 17 July 2002

Interviewer: What are the main risks your organisation faces?

Interviewee: It is important to recognise what our company is. Our company is the run-off vehicle. We do not write any new business. The risks we face are centred around the management of our liabilities. It is fair to say that the long-term liabilities completely dominate in terms of our uncertainty. The asset side, it is important we have appropriate investment strategies for the company. We minimise any overall risk to the company. The biggest uncertainty by far is asbestos liability. At 31 March 2002, gross undiscounted asbestos liabilities amounted to £6.4 billion, equivalent to more than 50% of the Group's total gross undiscounted claims reserves. In addition, we have many other types of liabilities such as pollution losses.

Interviewer: In what way does your company investigate its risk profile?

Interviewee: We are trying to make ourselves experts in understanding all the different types of claims liabilities that we face. By the nature of our company, we tend to rely on in-house knowledge and expertise more than anything else in terms of understanding those risks.

Interviewer: To what extent is your company able to use these techniques for solvency testing?

Interviewee: We do sensitivity testing, scenario testing. We also do stochastic modelling at the relatively high level to pull all different classes of liabilities together. We do not do stochastic simulation at the micro claims level. The primary reason of doing stochastic modelling is that we want to make sure that our investment strategies are the most appropriate taking into account the long-term nature of our liabilities. That is the most important use of DFA. We use sensitivity testing and scenario testing most definitely. It is stochastic simulation that we use to test the appropriateness of investment strategies.

Interviewer: How does your company establish which risk factors should be tested?

Interviewee: It is quite judgmental. It is very much driven by what we are actually using the modelling for. If it's been used to test the appropriateness of investment strategies, it's important to know what are the things which are going to impact that.

Interviewer: How many scenarios does your company use?

Interviewee: We have one central set of assumptions, which are based on our balance sheet. We look a range of around optimistic and pessimistic cases. We don't run a great deal of scenarios.

Interviewer: To what extent is your company able to allow for interactions between assets, liabilities and other factors?

Interviewee: There are lots of correlations between assets and liabilities, but most of them are quite weak. The only one we explicitly allow for is pricing inflation. That's the key driver.

Interviewer: Does your company use Wilkie investment model?

Interviewee: Yes, we use Wilkie investment model as part of our main model. If we feel that it could be distorting things because of particular questions we are trying to answer, sometimes we would use other models such as basic random walk model. It is the long-term results in which we are interested. Therefore, we use Wilkie investment model.

Interviewer: Is the model you use an in-house model?

Interviewee: Yes, it is an in-house model.

Interviewer: Have the results of DFA investigations ever directly led your company to take any material measure in underwriting or investment operations?

Interviewee: Yes, they have, in particular, in investment operations. We use DFA to evaluate investment strategies. For example, what is the appropriate proportion to invest in equities? It led directly to the decision of equity investment. The DFA results also change our precise investment strategies in bond market. However, the DFA results have never led any changes in our underwriting operations.

Interviewer: Is there any factors which limit the ability of your company to use DFA techniques?

Interviewee: The biggest factor is the parameterisation of the model, particularly on the liability side. Most of the parameters are selected subjectively. Time is another factor because parameterisation takes much time.

Interviewer: What features of the DFA techniques does your company plan to improve in the next one to three years?

Interviewee: Nothing in particularly. We continue to update and find the parameters we put into the model to reflect the latest market conditions and the latest assessment of assets and liabilities. I wouldn't say there is any overall improvement we intend to make.

Interviewer: What are the reasons for not producing financial condition report or its equivalent?

Interviewee: I do think FCR is in concept a good idea for the industry. It's an appropriate framework. It's just the nature of our company. We have other reports covering similar things.

Interviewer: To what extent do you think whether it is necessary to introduce a Guidance Note on financial condition report specifically for insurance companies carrying on general business?

Interviewee: If it is mandatory to produce FCR, it would be essential to introduce a Guidance Note.

Interviewer: To what extent do you think whether a financial condition report is a worthwhile exercise?

Interviewee: I think it is a good idea. It would fairly minimal benefit for companies such as us. For companies writing new business, it is something which is definitely encouraged. The concept is very good, but practically it may have to go through a very long learning process to get it work and get it to be effective.

Interviewer: Does your company plan to produce financial condition report in the next one to three years? If yes, what will be the key features of the report?

Interviewee: If it is required by the regulator, we will do. We think we cover most areas of the risks the company face in other report.