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QUANTIFYING OPERATIONAL RISK IN GENERAL INSURANCE COMPANIES

Developed by a Giro Working Party

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ABSTRACT

The paper overviews the application of existing actuarial techniques to operational risk. It considers how, working in conjunction with other experts, actuaries can develop a new framework to monitor/review, establish context, identify, understand and decide what to do in terms of the management and mitigation of operational risk. It suggests categorisations of risk to help analyses and proposes how new risk indicators may be needed, in conjunction with more normal quantification approaches.

Using a case study, it explores the application of stress and scenario testing, statistical curve fitting (including the application of extreme value theory), causal (Bayesian) modelling and the extension of dynamic financial analysis to include operational risk. It suggests there is no one correct approach and that the choice of parameters and modelling assumptions is critical. It lists a number of other techniques for future consideration.

There is a section about how 'soft issues' including dominance risk, the impact of belief systems and culture, the focus of performance management systems and the psychology of organisations affect operational risk. An approach to rating the people aspects of risk in parallel with quantification may help give a better overall assessment of risk and improve the understanding for capital implications.

The paper concludes with a brief review of implications for reporting and considers what future work will help develop the actuarial contribution. It is hoped the paper will sow seeds for the development of best practice in dealing with operational risk and increase the interest of actuaries in this emerging new topic.

KEYWORDS

Operational Risk; Enterprise Risk Management; Risk Management; General Insurance; Quantification of Risk; Financial Services; Capital Assessment; Capital Management; People Process and Systems; Curve Fitting; Risk Management; Regulations and Risk; Capital Regulations; Risk Categorisation; Risk Indicators; Bank of International Settlements; Extreme Value Theory; Stress Tests; Scenario Analysis; Causal Models; Bayesian Techniques; Soft Issues; Myers-Briggs; Belbin Team Roles; Risk Reporting; Professional Guidance

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In physical science the first essential step in the direction of learning any subject is to find principles of numerical reckoning and practicable methods for measuring some quality connected with it.
Lord Kelvin (1824-1907)

The lament of many an Institute working party member: "It is late and I want to go home."
Shaw (3 December 2003)

1. Introduction

1.1 *The Starting Point*

1.1.1 In the wake of a number of recent business failures and results which the stock markets see as overly volatile (or unpredictable), an even more professional and thorough scientific approach to business and risk management is increasingly sought.

1.1.2 The financial services industry (be it banking, insurance or securities) has its own approaches to risk that recognise the specific nature of the business environment. Led by the thinking of working groups at the Bank of International Settlements (Basel), typical risk categories include (a) credit risk; (b) market risk; (c) liquidity risk; (d) insurance risk; (e) operational risk; (f) other risk (strategic and reputational risk); and (g) group risk.

1.1.3 The immediate trigger for this paper is a call from the Financial Services Authority (FSA) for insurance companies to improve their approaches to operational risk. Perhaps it is natural, given that much work has already been undertaken on the modelling and measurement of credit, market, liquidity and insurance risk, for attention to turn to operational risk.

1.1.4 In these early days it is not possible to claim that best practice exists, so this paper attempts to set out the emerging actuarial approach which we hope will be a useful contribution to the development of best practice. Some of the techniques are not new, but their application in the field of operational risk is. The working group hope that this is a timely contribution to the development of actuarial thinking in a subject that might otherwise get overlooked.

1.1.5 Another objective of this paper is to guide the reader through a number of different areas related to the classification and quantification of operational risk. A further goal is to raise sights and go beyond what some may see as the typical actuarial world.

1.1.6 Operational risk can be described as "the risk of direct or indirect loss resulting from inadequate or failed internal processes, people and systems or from external events" (based on references from both Basel and the FSA). Despite the fact that definitions of operational risk do vary, they are broadly similar in scope, in that operational risk refers to loss from internal failure and/or external events not captured in the other risk categories. As discussed in the paper, aspects of 'other risks', such as strategic decision taking, reputational or legal, may or may not be regarded as categories of operational risk, but clearly need including in any overall risk framework. Indeed, it has been further pointed out that not having the right processes in place to manage operational risk is indeed itself an operational risk!

1.1.7 Considerable discussion has taken place about where operational risk starts and where proper corporate governance, including strategic decision taking, ends. In some ways this is a hollow debate. Ultimately to mitigate and manage operational and strategic risk we need:

— *design*: the right controls, people and processes;
— *implementation*: reviews to make sure controls are implemented with trained and motivated people working in an appropriate cultural environment; and
— *review*: processes to ensure a continual rethink and refresh of the whole.

1.1.8 The current strong push of emerging regulatory requirements alluded to above is accepted, but we believe that the real driver is, and properly should be, the pull of business benefits. Some of the best run and most professional companies have been developing their own approaches to operational risk for their own business reasons. Indeed, measurement of risk is becoming an essential tool of effective business management. Some of the best-run companies have now embedded risk management, in all its guises, in their way of doing business. Clearly those companies believe that it enhances their profitability, whilst at the same time reducing earnings volatility (and ultimately the risk of going out of business). Some of their thinking draws heavily on risk process and quality management in other industries — manufacturing, construction, retailing and engineering, to cite a few examples. Some of it is directly related to the characteristics of the finance industry. Much is possible now with the ever-increasing power of computers that even a few years ago would have been infeasible. However, discussion within Basel, the FSA and the European Union has clearly accelerated interest, understanding and action and even these forward thinking companies have benefited from the new ideas.

1.1.9 Whilst this paper originates from a General Insurance Research Organisation (GIRO) working group on operational risk, its application is much wider, covering life assurance, fund management, pension funds, other forms of security business and banking — indeed any organisation using analytic approaches to risk identification, management and measurement, including stochastic risk analysis modelling techniques.

1.1.10 In 2001 an operational risk working group was set up that reported at the 2002 GIRO conference in Paris. A good start had been made, but there was more to do, especially in the desire to be able to quantify operational risks and understand both their magnitude and correlation (or otherwise) with other risks. A second working party, with the colourful title

'Measurement or Bust', was established, and the authors of this paper were the key contributors to that work.

1.1.11 Adding value to business management often requires measurement and quantification. Management decisions are better informed by a well considered understanding of the scale of investments and returns. While it remains a challenge to keep the right balance between numerically-based logical decisions and more intuitive qualitative thought, the better the thinking from all angles the better the chance of success. In this context it is still easy to shy away from discussing, let alone quantifying, risk appetite or risk tolerance, and still unusual to find a well articulated well defined clear statement at Board level. This state of affairs is unlikely to last long. This paper contributes to resolving aspects of this quantification challenge.

1.1.12 Quantification requires data. The initial reaction is often that operational risk is difficult, if not impossible, to quantify, and even if it were not, the range of incidents (losses) would be hard to categorise, and hard to predict. The conclusion is that collecting data is a time consuming and possibly meaningless task. This thinking is being overturned, and, as an example, the United Kingdom banks have contributed to a confidential central database facilitated by the British Bankers Association (BBA) known as Gold. Also, across the globe there are emerging proprietorial databases such as 'OpVar', and Basel has just completed its second loss quantification exercise.

1.1.13 Sadly, insurers appear to be lagging behind, and to be relatively slow to get going, although the signs are that this is changing. One source of data might be the claims experience emerging from insurance policies underwritten to cover insurable risks arising from operational loss events. From our point of view this is not only a difficult source to access because of commercial confidentiality, but also the data are probably biased, due to limitations of insurance policy wordings (coverage) and the way insurance claims processes work, not to say incomplete.

1.2 *The Actuarial Contribution*

1.2.1 Operational risk is a broad subject. Many skills and types of expertise are required, and whilst the authors feel that the actuarial profession can make a significant contribution, we cannot do so alone. Indeed, others have been working with operational risk problems for some time, and we can listen and learn.

1.2.2 During the ground work for this paper we talked with a wide variety of people and are particularly appreciative of their openness and willingness to share ideas. Amongst others, members of the Institute of Risk Management, insurance underwriters, auditors, compliance specialists, engineers and occupational psychologists all have skills and all show a considerable interest.

1.2.3 Typically, one of the actuary's key tasks is to assist with the quantification of capital and risk, preparing analyses and reporting to the Board (or even the FSA). The profession has been actively involved during development of recent FSA consultation papers and, over the years, with appropriate guidance, in fulfilling a number of relevant and important roles.

1.2.4 Our work involves liaison with other professions, with company management or functional experts, and with external advisors. We can act as integrators in the quantification task — pulling the threads together on behalf of a diverse set of contributors. Our profession supports us, and, if necessary, enables us to say the unsayable.

1.2.5 This paper considers wide aspects of risk management and mitigation, well beyond the identification and reporting of risks. We hope that it will serve to provide pointers for the expansion of our thinking and further involvement in wider aspects of projects to support capital assessments for the FSA and for business management requirements. We hope that it will encourage readers to explore what they can learn from observing others and to develop new behaviours and techniques.

1.3 *Quantification Techniques*

1.3.1 There are many quantitative methods that might be applicable to the problems of understanding and quantifying operational risk. It is still early days in investigating which are likely to be most useful. We have set out below a list of those which we feel represent emerging best practice, and which we believe may have increased applicability in the future.

1.3.2 The methods are grouped into families under common broad headings. Some of these methods are discussed in subsequent sections.

1.3.3 *Statistical/curve fitting*: the statistical/curve fitting methods cover: (a) empirical studies; (b) maximum loss approach; (c) theoretical probability distribution functions (PDFs); and (d) regression analysis.

1.3.4 *Frequency/severity analysis*: this covers: (a) frequency/severity analysis; (b) extreme value theory (EVT) — which is an advanced version of frequency/severity analysis; and (c) stochastic differential equations.

1.3.5 *Statistical (Bayesian)*: the statistical/Bayesian approach includes: (a) systems (dynamic) models; (b) influence diagrams; (c) Bayesian belief networks and Bayesian causal models; (e) process maps and assessments; and (f) neural networks.

1.3.6 *Expert*: here we include: (a) fuzzy logic; (b) direct assessment of likelihood/preference among bets; (c) the Delphi method (see ¶2.7.8); (d) capital asset pricing models (CAPM) — market view less insurance/asset risk values; and (e) RAMP.

1.3.7 *Practical*: then there are the practical approaches of: (a) stress testing and scenario analysis; (b) business/industry scenarios; (c) dynamic financial analysis; and (d) market beta comparison for individual companies within market sectors.

1.4 *Paper Overview*

1.4.1 The paper is both theoretical and illustrative. We start by describing a hypothetical case study of an insurance company, the aptly named Middle England Life & General plc, that brings out many of the salient points and ideas.

1.4.2 The next two sections provide the background to the quantification of operational risk. Building on the case study, we discuss the framework for the assessment and quantification of operational risk and then present details of an initial risk assessment.

1.4.3 The middle sections of the paper address the quantification of operational risk. Stress testing and scenario analysis are discussed first, followed by a section on frequency/severity modelling, then an introduction to the not so well known topic of causal/Bayesian approaches to risk, and finally reference to the more widely used dynamic financial analysis methods.

1.4.4 The penultimate two sections look at the bigger picture. Various pitfalls and soft issues are addressed, followed by a section considering how to report the results and bring the threads together.

1.4.5 Finally, we make some concluding remarks and set out ideas for future work.

2. Case Study

2.1 *Introduction*

2.1.1 A key objective of this paper is to examine the applicability of various methods for quantifying operational risk, and quantification requires data. In the absence of any reliable data sources, we decided to create an illustrative case study: Middle England Life & General plc (MELG). Whilst we have not illustrated every aspect of operational risk, we have attempted to ensure the case study is:

- based in reality — by pooling data from public and private sources the underlying figures are intended to be reasonably illustrative of the type of losses, both in terms of order of magnitude (severity/impact) and likelihood (frequency);
- practical — by building on the personal experiences of working party members as well as published case studies, we hope it is sufficiently 'real life' to be a helpful tool — not just for this paper, but for other uses; and
- easy for readers to relate it to their own circumstances.

2.1.2 This case study is illustrative only. While the company overview, historic accounts and other data are based on realistic elements of various U.K. companies using FSA returns, any resemblance to any specific company is purely coincidental.

2.1.3 For the sake of clarity, the case study only discusses the general insurance aspects of the business. Furthermore, only a small number of risks are described in detail, out of a possible 135 or so possible categories (e.g. as given by the BBA level three categories discussed later and referred to in Appendix A). These include fraud, systems development, implementation of strategic decisions and reputational risk.

2.1.4 Following a FSA Arrow visit, the newly appointed director of group risk has been charged with producing a report that:

— reviews the enterprise wide risk management practices of MELG plc, with particular reference to operational risks;
— ensures that MELG plc takes steps to establish and maintain appropriate risk management practices, adhering to any FSA regulatory guidelines about operational risk management and other best practices; and
— informs the group risk committee about past and current enterprise wide risk management issues, with a focus on exposure to operational risks.

2.1.5 The report is to investigate the past, current and projected future of the company, quantifying issues wherever possible and setting out findings, without fear of retribution, under the 'whistle blowing rules' from the group procedures.

2.2 *Historical Beginnings of MELG*

2.2.1 The company's origins in the U.K. may be traced back to the early 1900s, when it started as a small life office, based in the Midlands. In these early days it diversified into non-life business and started to offer private motor insurance and then other 'personal' lines. A direct writing operation was launched in 1993. Although MELG developed a commercial motor account, it was only when it acquired a commercial insurance company in 1995 that it became a serious commercial insurer. In 1997 MELG restructured into three separate business units — commercial, personal intermediary and personal direct.

2.2.2 In the summer of 1998 MELG became the target of a hostile takeover bid, which was eventually successful. The company became, with effect from January 1999, the U.K. subsidiary of a large multinational company, with its parent Megacentral Insurance Corporation Inc (MICI) based in New York, United States of America.

2.3 *Current Operations of MELG*

2.3.1 MELG plc currently operates through three major sites (one in the north, one in the Midlands, where its head-office is co-located with an operational site, and one in the south) with ten local offices. Its profitability has generally been in line with market averages.

2.3.2 There are 2,600 general insurance staff, of whom 900 are in its

Midlands office, 600 in each of its north and south offices and 500 spread over the ten local offices, including a team of 50 inspectors (broker sales force), and 50 external claims staff.

2.3.3 It operates a matrix management philosophy. Each executive team member 'owns' one of its key business processes and has a responsibility for its improved quality across the whole organisation. The organisation is now considered as three main strategic businesses:

— commercial insurance;
— personal intermediary insurance; and
— personal direct insurance.

2.3.4 The parent company (MICI) is a global insurance company based in New York, U.S.A. It is a centrally managed global firm with operations in 50 countries. The group management is powerful, and has tended to determine the group strategic and investment policy on behalf of its local operations. MICI now finds itself to be in financial difficulties with its U.K. operations, which it believes to be the result of the way in which group strategic investment policy was implemented and a large external weather catastrophe in 2000, combined with inadequate reinsurance purchasing.

2.3.5 MELG plc has a limited degree of autonomy from its parent company. Its Board meets eight times a year and as well as three executive directors, the chief executive officer, the finance director and the group operations director, it has three representatives from its parent and two external non-executive directors. It is required to submit plans on an annual basis with results and updated forecasts on a monthly basis. As well as accounts, it submits a series of key performance indicator management information.

2.3.6 MELG plc still faces multiple legacy systems and ongoing systems integration problems, so production of consolidated management information is unreliable. This further hampers the effective running of the group from the centre. The three separate business units underwrite diverse types of cover with different structures and cultures, which again make centralised control difficult and exacerbate already poor financial and underwriting disciplines. There appears to be a very high expense ratio and large losses as the firm tried to compensate for previous under-pricing and under-reserving. Merger costs were higher than expected, and MELG has made little headway in achieving the forecast cost-side synergies.

2.4 *MICI imposes Investment and Business Strategy*

2.4.1 In July 2000 the parent company (MICI) set an aspect of policy for MELG that was based on group investment objectives. This proved to have a detrimental effect on MELG. MELG plc did not completely check the suitability of the investments made on its behalf by the parent company. It appears that the MELG plc balance sheet was used to make strategic

Table 2.4.2. 70/30 personal/commercial split; projection

£ million	2001	2002	2003	2004	2005	2006	2007	2008
Personal lines	1,609	1,808	1,900	1,995	2,095	2,199	2,353	2,518
Commercial lines	298	497	697	1,045	1,145	1,219	1,294	1,369
Total gross premium	1,907	2,305	2,597	3,040	3,240	3,418	3,647	3,887
U/W result	−102	−76	−50	0	32	3	−50	−100
Net assets	1,700	857	1,043	1,332	1,538	1,747	1,917	2,128
Solvency ratio	75%	51%	55%	60%	65%	70%	72%	75%

Table 2.4.3. 90/10 personal/commercial split; projection

£ million	2001	2002	2003	2004	2005	2006	2007	2008
Personal lines	1,609	1,808	1,900	1,995	2,095	2,199	2,353	2,518
Commercial lines	298	497	500	450	425	400	380	360
Total gross premium	1,907	2,305	2,400	2,445	2,520	2,599	2,733	2,878
U/W result	4	−76	−50	10	52	75	100	50
Net assets	1,700	857	1,050	1,350	1,600	1,850	2,150	2,600
Solvency ratio	75%	51%	63%	81%	96%	109%	120%	135%

investments for the U.S.A. parent. The subsequent market downturn in the U.S.A. has resulted in significant losses, as at April 2003.

2.4.2 A group management decision to aim for 70% personal lines and 30% commercial lines business mix was also taken in July 2000. This split was to be achieved for 2001 onwards. This business mix decision was imposed on the U.K. management team, who, at the time, would have preferred to maintain a 90/10 split between personal lines and commercial lines. Anecdotal reports suggest that the U.K. management may have been pressurised to improve the projected commercial lines loss ratios beyond that which they felt was realistically achievable during the business planning process. Their final projection for group on a 70/30 split was as shown in Table 2.4.2.

2.4.3 The U.K. management team's minority report at the time showed the final projections on a 90/10 basis (adjusted in all other respects to be comparable with the 70/30 split), and this is shown in Table 2.4.3.

2.5 *Management Changes*

2.5.1 The MELG management decision-making process changed during 1999, following its acquisition by MICI. Prior to that time it operated a more consensus, delegated decision-making style. The cultural change has been a difficult one, leading to the eventual resignation of its long-standing U.K. chief executive officer, followed by that of the finance director a few months later. There was no suggestion of poor management at that time — the culture clash had become a real point of friction. However, since then many problems have been blamed on previous management.

2.5.2 The current CEO was appointed by the parent company (MICI) in January 2002. After three months he appointed his own senior team, including one outsider, the FD who came from a 'FMCG' background, and who had previously worked with the CEO in a retail environment.

2.5.3 The new CEO's own background included spells at a bank, and before that at a firm of accountants; he accepts that this was some time ago. His most recent experience was in retail (in New York, U.S.A.), where he gained a reputation for acquiring smaller businesses and implementing centralised back office functions that enabled significant staffing level reductions and associated cost savings. He is also a personal friend of the parent company chairman, having known him since their university days.

2.5.4 In mid 2002 MELG had its first FSA Arrow monitoring visit. The net result was that the FSA required MICI to transfer £100m to its U.K. subsidiary.

2.6 *Current Position*

The date is now April 2003. The company has just finalised its 2002 accounts. The gross earned premiums and some financial outcomes for 1995-2002 (actual) are set out in Table 2.6.1, together with a breakdown between personal and commercial lines.

2.7 *Some Major Historical Actions and Incidents*

2.7.1 *Launch of direct writing.* In mid 1993 a new direct channel was launched. The projected cost at that time was £30m to P & L, based on a new marketing budget of £10m per annum, extra staff costs and a £5m investment in systems, all offset by growth of business and eventual profit. A retrospective analysis undertaken in 1998 suggested that the actual cost was in the region of £70m, partly due to expense overruns and partly to lower than expected business growth. For the ease of analysis, it was decided to assume that the loss had an effective date of 1998, as the problems were more to do with the later stages of implementation than the original decision.

Table 2.6.1. Gross earned premiums and some financial outcomes for 1995 to 2002

£ million	1995	1996	1997	1998	1999	2000	2001	2002
Personal lines	1,001	1,204	1,297	1,305	1,409	1,597	1,609	1,808
Commercial lines	77	112	139	167	199	240	298	497
Gross premium	1,079	1,316	1,436	1,473	1,609	1,838	1,907	2,305
U/W result	189	270	82	74	−19	−206	−102	−76
Net assets	539	865	1,170	1,427	1,735	1,500	1,700	857
Solvency ratio	50%	81%	101%	118%	131%	99%	75%	51%

2.7.2 *Outsourcing of claims handling.* The structure of the three current, separate strategic business units was established in January 1997. The commercial insurance business was self-contained and largely staffed by people from the acquired commercial company. The personal direct business, which had previously been considered a sales channel of the personal lines business, was now given autonomy for all aspects of its business. In the event, it decided to outsource its claims handling (post initial notification) to the personal intermediary business. The projected cost of this change was £10m. A retrospective analysis suggested that the real cost had been nearer £50m, comprising loss of revenue £30m, extra expenses £5m (not saved) and poorer loss ratio £15m as a result of attention being distracted from underwriting and inadequate monitoring of claims handling. There were also a number of cultural tensions.

2.7.3 *External supplier fraud.* A major case of external fraud led to a further loss of £5m, spread throughout the 1999 calendar year. The fraud involved a third-party supplier selected by the U.K. company to provide services to insurance clients. The fraud was reported in 2001 by an employee at the supplier. Subsequent investigation revealed that a junior manager at the company was aware of potential irregularities, but had not disclosed this information due to lack of confidence in whistle blowing procedures.

2.7.4 *Reinsurance failure to respond.* Group management also overrode local management with respect to reinsurance policy. On the occurrence of a large external catastrophe in March 2000, with a gross loss of £100 million, only £10 million was recovered from the catastrophe XL reinsurance treaties, instead of the £50 million that had been expected. The local U.K. management blamed the group risks department in New York, which had reviewed the reinsurance programme and agreed the terms with the lead reinsurer. The group risks department blamed the U.K. management for failing to spot the problems with the final draft reinsurance treaties that had been sent to the U.K. team for final approval. The group internal audit department blamed both parties for their evident lack of communication. The overall result was an unexpected loss of £40m.

2.7.5 *Block account loss.* A key corporate relationship for MELG plc collapsed in January 2001, primarily as a result of the group initiated management changes at MELG plc in September 2000. The key corporate partner was unimpressed by the new business development manager from Chicago (U.S.A.), and decided to invite competitive tenders for the contract renewal on 1 January 2001. As a result, this £100m 'block account' (personal lines) was lost, with an assumed profit value of £20m.

2.7.6 *Loan default investment loss.* As previously mentioned, the parent company had, in effect, set an aspect of investment policy that had a detrimental effect on MELG plc because it put group objectives before the prudent management of the U.K. insurance firm. Group management in the U.S.A. overrode local decisions in the U.K. Local management either lost

Table 2.7.8. Delphi assessment

Year	Number of incidents	Total cost (£m)
1995	15,000	3.000
1996	12,000	2.220
1997	22,000	4.510
1998	15,000	3.255
1999	23,000	5.060
2000	20,000	5.040
2001	15,000	4.005

autonomy or they did not properly check the suitability of the investments being made. Group management in the U.S.A. effectively used MELG's balance sheet to make strategic investments on a group wide basis. One such strategic investment, a loan to a key producer in the U.S.A., defaulted (in October 2002), costing £75m.

2.7.7 *Stop loss reinsurance loss.* The MELG stop loss reinsurance treaties for its gross loss of £50m should have recovered £25m, but there was a nil recovery. Once again the MICI group risks department and the U.K. management blamed each other for the problem. The result was an unexpected loss of £25m.

2.7.8 *Delphi assessment.* A recent 'Delphi' method assessment of fraudulent and 'misrepresented' claims leakage led to an assessment of over payment of claims, which is shown in Table 2.7.8. (This had involved seeking the views of 12 internal claims personnel and three external experts based on some preliminary data analysis, summarising these views, replaying them back to the 15 people, letting them refine their views in light of the comments of others and then collating these refined views.)

2.7.9 *Systems overspend loss.* Systems developments often led to overspends. In the last seven years there have been twelve major overspends averaging £2.2 million. A new project was planned recently, again influenced by group management. Its outline budget cost for 2003/04 is £20 million. It is already three months behind schedule and there is an overspend of £2m compared to the phased budget. The system specification had been developed to incorporate group and company requirements, but without effective co-ordination. The result also appears to be probable weaknesses in reporting of third-party supplier transactions.

2.7.10 There were one or two other relevant losses, and two 'near misses'. The risk director was told during various interviews about a number of things that could have gone wrong, but did not, and hence the data collected refer to events which could have resulted in larger operational risk losses.

2.8 *Consequences*

2.8.1 The FSA Arrow monitoring visit in mid 2002 highlighted a series of issues and concerns which led to a full investigation. The net result was that the FSA required MICI to transfer £100m to the U.K. to maintain an adequate solvency margin for MELG plc over the foreseeable future.

2.8.2 Although generally holding a good reputation with both intermediaries and customers, following the loss of its major household-based account and the stock market collapse there has been recent press speculation that its financial position is less than satisfactory. The claim was that its American parent might not stand behind it if the worst came to the worst, and this is causing a nervous reaction from smaller brokers and direct purchasers. This reputational risk could easily blow up into a full scale crisis.

2.9 *Initial Response to Information*

2.9.1 The risk director's first step was to ensure that the role was clear and that the reporting lines were independent of any senior management influence.

2.9.2 The next consideration was to understand the key drivers behind the task — the rationale for the operational risk review in terms of meeting the FSA requirements and improving management disciplines. The initial discussions highlighted a lack of any real concerted discipline to risk management or any clear risk management policies. There was, for example, no agreed Board statement about risk appetite or tolerance under the current circumstances.

2.9.3 The subsequent more detailed preliminary investigations highlighted the fact that the available information was incomplete. In addition, there were too few losses on which to base any model. The known losses did not reflect all the risks that the company faced, as all those risks that had not so far resulted in a loss had been ignored.

2.9.4 The risk director therefore decided to pursue additional information including, for the known losses:

— clarification of when losses were recognised financially (i.e. the accounting quarter that took the hit) and when they were incurred (i.e. when the action or decision that led to them occurred);
— the expected profit that would have accrued to the bottom line if the block account had not been lost, as the lost income was not a good measure of the actual financial loss;
— where a loss amount is made up of several effects, such as expense overrun, inappropriate assumptions and resourcing issues, then whether it is possible to isolate the losses due to each effect; and
— interviewing staff involved in the project/area where each loss arose, and those who investigated it, on an informal basis, in order to get a more detailed picture of events. The aim is to understand what happened, look for the causes of the loss, and look for points at which the loss could have been mitigated, but was not, and the reasons.

Table 2.9.9. Operational risk loss events

Year incurred	Year recognised	Loss	Loss category	Loss amount
1993	1998	Launch of direct writing	Strategic implementation and expense overrun	£40m
1997	1997	Outsourcing of claims handling	Outsourcing/supplier control	£50m
2000	2002	Stop loss reinsurance fails to respond	Legal (contract wording)	£25m
2000	2002	Investment strategy	Loan default	£75m
2000	2001	Loss of block account	Loss of a key customer	£20m
1999	2001	External supplier fraud	External fraud	£5m
2000	2000	Reinsurance fails to respond	Legal (contract wording)	£40m
1995 to date	1995 to date	Claims leakage — model separately	External claims fraud	various
1996 to date	1996 to date	System overspend — model separately	Expense overrun	various
1996	1998	Various facilities contracts placed with friends of the facilities manager	Internal fraud	£7m
1999	1999	Flaws in cascaded training programme for new system (near miss)	Transaction capture, execution and maintenance/training	£15m
1999	1999	Telephone system failure (near miss)	Damage to systems	£9m
2001	2001	Error in delegated authority contract wording (near miss — not spotted by cover holder)	Legal (contract wording)	£12m

Table 2.9.10. Summary operational risk loss events

Financial year	Number of losses	Amount of losses (£m)
1995	0	0.0
1996	0	0.0
1997	1	50.0
1998	2	47.0
1999	2	24.0
2000	1	40.0
2001	3	37.0
2002	2	100.0
Total	11	298.0

2.9.5 There is a high probability that the list might not include all the losses that have actually been incurred. The risk director, therefore, decided to interview key staff who might be aware of other losses that were either turned around in time or which were absorbed in the financial results (say by improvements elsewhere covering them up), to see if any additional losses or near misses should be added to the list for analysis.

2.9.6 In addition, he decided that a full risk identification exercise would have to be performed, in order to find those risks that have not yet resulted in losses. We do not discuss this exercise further, as it is outside the scope of this paper.

2.9.7 There is also the question of whether all the losses in the list are, in fact, operational losses. For instance, there is some debate as to whether the loss due to the impact of the imposed business mix is an operational loss or a strategic loss. Some would argue that this is a separate category of risk and not part of operational risk, because a strategic decision is a deliberate choice made about the direction of the business. The alternative view is that, while strategic choice clearly influences the chance of success and risk profile, many aspects of the strategic decision process and the execution of that strategy are operational. In this instance the group risk director decided that this was a strategic loss, and omitted it from his list of operational losses.

2.9.8 There is the further question as to whether some of the reinsurance losses were inadvertent insurance losses. In the event the risk director decided that the lack of proper procedures meant they should be classed as operational losses.

2.9.9 As a result of these additional investigations the complete list of operational risk loss events is prepared as in Table 2.9.9.

2.9.10 In order to facilitate modelling, including where judged relevant near misses, this can be re-expressed as in Table 2.9.10.

2.9.11 The group risk director now has some data to use in the modelling that he intends to perform. The approach to this modelling is described in later sections.

3. A Framework for Assessing and Quantifying Operational Risk

3.1 MELG's new risk director next looked at the overall framework for risk management, and how operational risk could be defined. The consideration of what data might be required in order to model operational risk was part of this exercise.

3.2 *A Risk Management Framework*

3.2.1 The risk director found that, although there was some awareness of risk management issues in MELG, there was no effective framework. This had been noticed by the FSA in their Arrow visit, and was a major issue in the resulting mitigation plan (FSA, 2003a). A top priority was therefore to set up a risk management framework that worked.

3.2.2 The risk director decided to adopt the commonly used control cycle approach (IRM, 2002), as shown diagrammatically in Figure 3.2.2.

3.2.3 MELG's risk director found that, because of the matrix

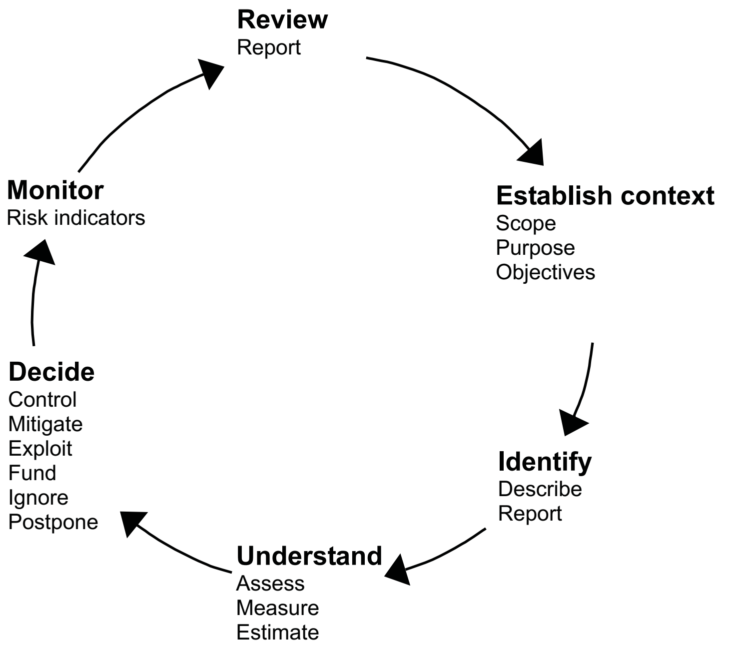

Figure 3.2.2. A basic risk management control cycle

management structure, there had been confusion as to how risk information was disseminated within the organisation. The priority given to risk management had varied widely, and there had been no consistent assessment of risk appetite.

3.3 *Risk Management Maturity Model*

3.3.1 There have been several attempts to describe the evolution of risk management practices in general, and those for operational risk management in particular (BBA, 1999; Fox, 2005; Hall, 2002; Risksig, 2002; Hoffman, 2002). They differ in detail, but agree on the overall outline, shown in Figure 3.3.1.

3.3.2 MELG's risk director concluded that MELG was at or near the awareness stage. It had been relying on traditional measures (internal controls, internal audit, quality of its staff) to control operational risk, but had just realised that this was not enough — hence the new risk director role.

3.3.3 The risk director felt that a reasonable short-term goal was to reach the monitoring stage. To do this would mean having a comprehensive

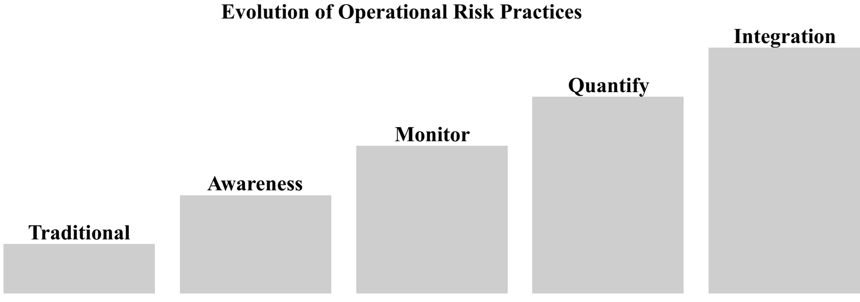

Figure 3.3.1. Risk management maturity model

set of risk indicators along with corresponding escalation triggers and an effective risk reporting process.

3.3.4 In the medium term the risk director wanted to achieve quantification, with a loss database, quantitative targets for improvement and good techniques in place for predictive analysis.

3.3.5 The risk director decided to propose to the Board that reaching the integrated stage should be a strategic goal for MELG. This would require MELG also to identify correlations between risk indicators and to link compensation to returns adjusted for operational risk as well as other risk types. The Board would need to consider the cost, in management time and overall resources, before deciding whether this was an appropriate strategic goal, or whether reaching the quantification stage was sufficient.

3.3.6 In the context of these goals, the push from the FSA Arrow visit and the internal drive for value added, the risk director's first formal paper to the group risk committee was one which set out the background to the project and initiated a discussion about what risk MELG could face, given its capital and business position. The paper referred to the FSA's comment about a 1 in 200 risk of insolvency in a one-year time frame, it then explored the concept of both one-year and longer-term (five-year) projections, and discussed the difficulties in using either on their own — the longer-term projections needed to allow for the impact of management action, while the shorter-term projections did not bring all the issues to light. It was noted that, as a rule of thumb, a 97.5% chance of not becoming insolvent in a five-year projection was seen as similar to a 99.5% of not becoming insolvent in a one-year projection — both based on the 1 in 200 thinking.

3.3.7 The opportunity was also taken to question whether the work was starting too far along the management thought processes, and that some issues related to the Board's own values, objectives and incentives. The paper articulated the need to balance short and longer-term views, encouraging openness and transparency as well as voicing concerns about dominance risk.

Some thought that this was a brave move, but knowing that support, if needed, would come from his profession, the risk director was confident that voicing the more important or sensitive things as soon as possible was the right approach.

3.4 *Risk Categories*

3.4.1 Throughout the identification, assessment (understanding) and decision stages of the risk management control cycle, it is useful to have a system of risk classification. This provides a framework for the reporting of risk, and helps to place risks within coherent groups.

3.4.2 The term *enterprise risk* is often used to refer to the sum total of all the risks faced by an organisation. Enterprise risk is commonly split into core business risk and operational risk, each of which is then further subdivided. Simplistically, core business risks are those that arise as a result of the business decisions taken by the management, while operational risks are those that arise as a result of the implementation of those decisions, or from outside factors.

3.4.3 In the *Prudential Sourcebook* (FSA, 2003c), the FSA identifies six major risk categories:

— credit risk;
— market risk;
— liquidity risk;
— insurance underwriting risk;
— operational risk; and
— group risk.

3.4.4 This classification is consistent with a division into core business risk and operational risk, though it should be noted that the FSA is not concerned with enterprise risk *per se*, but only with risks to its own objectives. Also, since then an 'other' category has been introduced to include strategic, reputational and even legal risk.

3.4.5 Other splits are possible. The Casualty Actuarial Society (CAS) uses four categories in its generic, all industry, classification (CAS, 2001; CAS, 2003): hazard risk, financial risk, operational risk and strategic risk.

3.4.6 This is difficult to reconcile with the division into core business risk and operational risk. Many of the risks classified by the CAS as hazard risks (e.g. theft/crime, fire/property damage, windstorm/other natural perils) would be considered as operational risks by non-insurance companies. It is not clear where insurance risk fits into the CAS classification — possibly as a financial risk for insurance companies. Of the four CAS categories, hazard risk and operational risk together seem to correspond to our notion of operational risk, and financial risk and strategic risk to our notion of core business risk.

3.4.7 Needless to say, once particular examples are examined, this neat two-way division appears increasingly arbitrary.

3.4.8 Other categorisations are possible. Basel has moved towards six (internal fraud; external fraud; employment practice/workplace safety; clients, products and business practices; damage to physical assets; delivery and process management), the FSA having started from four (people; process; systems; external events), seems to be moving towards Basel; based on the FSA's original thinking, the BBA, in establishing their database (Gold) for banking operational risk, mapped level 2 and level 3 categories on to these four headings: people, process, systems and external events (see Appendix A), but are in the process of refining their thinking — possibly to move more in line with Basel. If this happens, it may be that the 135 to 140 level 3 categories they use will reduce to something smaller, e.g. between 60 and 80.

3.4.9 Consider reinsurance risk. The question of what reinsurance cover to take out is a business decision, so the risk that the reinsurance programme is poorly chosen and proves unsuitable is a core business risk. So is the risk that the reinsurers do not pay claims. However, the risk that the chosen programme is not, in fact, implemented is not a core business risk: it would happen for reasons such as poor communication or incompetence, and is therefore an operational risk. This means that a failure to recover the expected amount could be a result of either a core business risk or an operational risk; we have to look to the cause rather than the consequence to determine which.

3.4.10 Reputational risk, i.e. the risk that loss will be suffered because of damage to the firm's reputation, is similar. If a systems failure leads to a breakdown in claims handling, a poor reputation and lower sales, then the loss has clearly arisen from an operational risk. However, if the firm loses its reputation because of a strategic decision that fails publicly, the resultant loss is a core business risk. Reputational risk is particularly interesting, as nearly anything that can go wrong, whether core business or operational, can result in a loss of reputation and a financial loss. Many risk classifications include reputational risk as an operational risk, regardless of the originating cause of loss.

3.5 *Cause and Consequence*

3.5.1 These and similar examples have led us to propose a basic framework for analysing risk based on the notions of cause and consequence. A single consequence can have more than one cause; a single cause can have more than one consequence; in order to analyse risk effectively it is necessary to work from the causes rather than from the consequences.

3.5.2 Figure 3.5.2 illustrates the way in which a number of causes can contribute to a collection of events that in turn have a number of consequences.

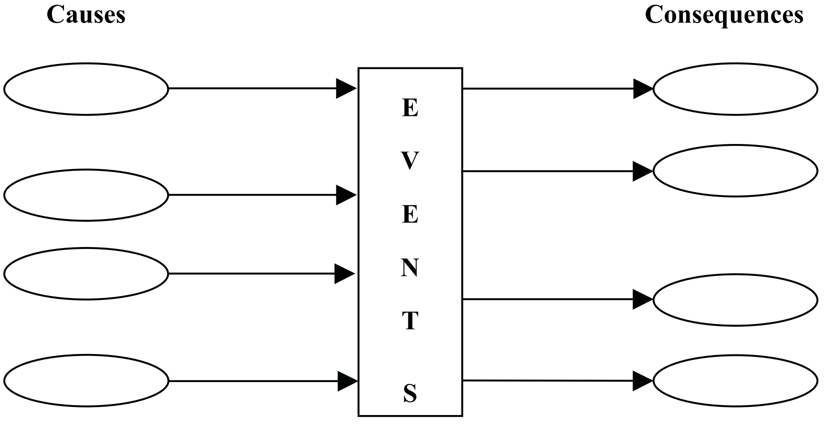

Figure 3.5.2. Causes, events and consequences

3.5.3 For example, consider some of the adverse financial effects in the Chicago Board Options Exchange (CBOE) that resulted from the market crash of 1987. Some examples of systems problems that arose during the crash are given below (MacKenzie & Millo, 2001):
— CSLOUCH, the risk management system at O'Connor & Associates, could only accommodate a move of 12% in one day, based on the worst daily loss that had been seen in the past (12.8% in 1929).
— The systems of many clearing firms could cope only with double-digit dollar prices. When option prices rose to, say, \$106, they appeared as \$6, and the trading firm's accounts with the clearing firms were off by millions of dollars, but at any one time it was impossible to tell in which direction.
— The markets at CBOE and the Mercantile Exchange were intimately connected, but their clearing systems were not linked, so what were actually well-hedged positions could be subject to huge margin calls.

3.5.4 In each of these examples a single consequence, a financial loss, arose from more than one cause; in these cases, from adverse market events exacerbated by systems problems. The loss is not solely attributable to any single cause, and so cannot be attributed to either a core business risk (the market event) or an operational risk (the systems failures); it is a combination of the two.

3.5.5 In general, we believe that, by analysing risk of financial losses in terms of causes, rather than consequences, it is possible to avoid many of the problems of double counting and omission. Reputational risk is often proposed as a risk category; however, loss of reputation is usually a consequence of other problems, such as systems failure or failure to meet regulatory requirements. If reputational risk is treated as a separate category, alongside systems risk and regulatory risk, there is a risk of double counting.

3.6 *Defining Operational Risk*

3.6.1 There is no single risk classification that suits all purposes. However it seems that many U.K. insurance companies are adopting the definition used by the Basel committee (BCBS, 2001) as a starting point. This defines operational risk as the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events.

3.6.2 Other definitions include:

— a measure of the link between a firm's business activities and the variation in its business results (King, 2001);
— operational risk is the risk of adverse impact to business as a consequence of conducting it in an improper or inadequate manner and may result from external factors (Doerig, 2000);
— operational risk results from costs incurred through mistakes made in carrying out transactions such as settlement failures, failures to meet regulatory requirements, and untimely collections (Pyle, 1997);
— operational risk is the potential for adverse financial developments due to effects that are attributable to customers, inadequately defined controls, system or control failures, and unmanageable events (Laycock, 1998); and
— risks deriving from a company's reliance on systems, processes and people. These include succession planning, human resources and employment, information technology, accounting, audit and control systems and compliance with regulations (McDonnell, 2002).

3.6.3 The FSA gives a number of examples of operational risks (FSA, 2003c), but avoid a hard and fast definition. They are more concerned that all risks are subject to effective management, rather than with the precise classification used.

3.7 *Practical Considerations*

3.7.1 In practice, what matters is that the organisation has good definitions for all its risk categories and uses them consistently. It may well be necessary to use different definitions for different purposes. For example, during the main part of the risk management control cycle it is very important to use a definition based on causes. The risk director saw that most of MELG's claims related problems were the result of operational failures, and hence were classified as operational risks.

3.7.2 However, when it came to assessing the capital that was required to fund the risks, the situation was different. The poor claims handling processes had hitherto been reflected implicitly as part of the loss reserves, as their effects were not stripped out of the claims data. Pending more sophisticated data collection procedures, the risk director was forced to leave them included in the insurance risk category.

3.7.3 MELG's risk director is aware of the categorisation problem for the claims handling risks, but it is easy to see that these risks could have been double counted.

3.7.4 A risk matrix is often used as a framework for risk identification and assessment. The probability assessment matrix used in the FSA's Arrow process is a handy example (FSA, 2003c). This gives a breakdown of risks by category and subcategory; each is then assigned a rating of high, medium or low.

3.7.5 Appendix B shows the risk director's first draft of a fairly high level risk assessment matrix that he uses as the basis of the process for MELG.

3.7.6 In many organisations the risk matrix is designed centrally, and then completed separately by each business unit. The matrix that we show has two levels of categorisation, not unusual for the firm-wide matrix. Within each business unit, however, there may be further levels of categorisation which may not be shown on reports sent outside the unit.

3.7.7 In practice, the risk matrix serves as a working definition for the different types of risk, including operational risk. If a risk appears in an operational category, then it counts as an operational risk. This is an effective operational definition.

3.8 *Data Collection*

3.8.1 While considering the overall risk management framework of MELG, the risk director started to address the problems of data collection.

3.8.2 The accuracy of risk measurement methods crucially depends on both the appropriateness of the model and the availability of data. An appropriate model requires a thorough understanding of what underlies the risk under consideration. This understanding is inherently linked to data availability, and thus the occurrence of events. Incidents also provide the basis for statistical testing of risk models. Furthermore, the accuracy of risk models depends upon the measurability of outcomes, and thus upon sound definition and understanding of effects.

3.8.3 Some form of data collection is vital for any effective risk management process; the problem is to decide what data should be collected. There are two opposing views: data collection should be driven by the needs of the models; or the models that are used should be driven by the availability of data.

3.8.4 MELG's risk director decided to steer a middle course, realising that the process of building effective models is iterative, and that the models and data requirements will be refined in the light of experience and lessons learned.

3.8.5 A good starting point is to collect data relating to losses and exposure.

3.8.6 The loss database is conceptually fairly simple, as it is very like an insurance claims database. For each event it should record information such as date incurred, date reported, the development of the loss amount (including initial estimate), and so on. It should also include the cause of the loss, in a form consistent with the categorisation used in the firm-wide risk matrix, as well as the consequence (how the loss manifested). However, there are a number of decisions that must be made:

— How are losses that arise from more than one cause tested? Should the loss amount be split between causes, or should the whole amount be allowed to appear under each cause?
— Should data on near misses — incidents that did not in the end result in any monetary loss — be collected?
— How should a blame-free procedure for reporting both actual losses and near misses, and avoid under-reporting be set up?

3.8.7 It is much more difficult to collect exposure data, as often there are no commonly agreed measures of exposure. To start with, some of the data used for risk indicators (see below) may serve as a proxy, such as number of renewals, number of claims, and so on. Another avenue of investigation would be the data used for activity-based costing; indeed, many of the difficulties associated with activity-based costing will arise in collecting exposure data for operational risks.

3.9 *Risk Indicators*

3.9.1 The risk director also decided that he needed to set up a monitoring system to provide early warning of high or increased risk. He chose to design a system of risk indicators.

3.9.2 Ideally, risk indicators should be both easy to calculate and predictive. This is difficult to achieve. However, they can be an extremely valuable component of the overall risk management process, for a number of reasons.

3.9.3 First, they can help with a qualitative assessment of risk. Even if an organisation cannot yet measure operational risk quantitatively, some sort of assessment is needed. The behaviour of risk indicators can indicate that qualitative, subjective assessments need to be changed or updated (FSA, 2003b). Second, risk indicators can be used for all risks, not only those with past losses. Third, risk indicators can be used to gauge the effectiveness of systems and controls. When a risk indicator falls outside its normal range, it indicates a possible operational issue (Hallock *et al.*, 2001). Fourth, risk indicators can be the basis of penalties and positive incentives that encourage managers to operate in a way that contributes to the reduction of enterprise wide operational risk exposures. They thus help to create a culture of risk awareness throughout the company.

3.9.4 There are several challenges to be overcome if the use of risk indicators is to be effective. It is often difficult to find good indicators; insurance companies have a plethora of risks and identifying the most appropriate is not simple. In practice, the difficulty of finding good indicators may limit the choice.

3.9.5 Although risk indicators can help to encourage a culture of risk awareness, they are difficult to use unless the company already has at least a rudimentary risk management framework. The risk director understood this, and saw the introduction of risk indicators as a good short to medium-term goal that would help to focus risk management efforts. He realised that he needed to set up some form of database in order to track the risk indicators, as well as to introduce a reporting system, so that the right people receive information that they can act upon.

3.10 *Finding Risk Indicators*

3.10.1 The FSA lists a number of risk indicators, including the number of customer complaints, processing volumes, employee turnover, large numbers of reconciling items, process or system failures, fragmented systems, systems subject to a high degree of manual intervention, and transactions processed outside a firm's mainstream operations (FSA, 2003b). Some of these may be difficult to quantify (such as fragmented systems), and others are not very predictive (system failures).

3.10.2 The desirability of leading over lagging indicators means that causal risk maps are useful guides when building a set of risk indicators. Risk indicators should be based on underlying causes, or intended to expose poor processes, rather than relying on outcomes.

3.10.3 Risk indicators can be classified into three categories:

— *Exposure-related indicators*, such as the number of claims handled. These are volume-based indicators that typically measure the throughput of processes with the potential for operational failure. Whilst helpful while the rate of loss remains constant, they cannot pick up changes in the loss rate. Also, operational risk is multi-dimensional, so that an array of such measures is required;

— *Loss-related indicators*, such as the number of customer complaints. These measure events associated with operational losses. However, they measure outcomes so are lagging indicators, and therefore insufficient on their own;

— *Cause-related indicators*, such as staff turnover. These generally measure factors identified as drivers for operational losses, and are therefore leading indicators. They are often the most difficult to identify, relying on a causal relationship between the indicator and an associated operational loss. They are often more complex than other types of indicators, but are the most valuable in use.

Table 3.11.1. Illustrative risk indicators

Risk indicator	Category	Comments
Number of unresolved internal audit issues rated 'severe'	Cause	Requires a tracking system for internal audit. Also consider using the number of internal audit issues unresolved after two years.
Staff turnover	Cause	May be a lagging indicator, as it may be symptomatic of other problems as well as leading to problems itself.
Training hours (or pounds spent) per staff member	Cause	Low numbers are bad here.
Number of staff members who require training	Cause	Measure separately for each staff category and type of training. Consider using ratio of untrained to trained staff.
Number of different desktop computer configurations in use	Cause	Inconsistencies can lead to problems, especially for inadequately trained staff.
Hours of paid overtime per staff member	Cause	May indicate that resources are stretched.
Number of claims processed	Exposure	May be a leading indicator, as it may indicate increased pressure on claims handlers. Consider using claims processed per claims handler.
Number of complaints	Loss	A lagging indicator, but nonetheless useful. Consider using ratio of complaints to claims processed.
Growth in sales	Exposure	Can be used to detect anomalies. May be a leading indicator for some risks.
Budget overruns	Loss	Consistent overruns may indicate failures in the budgeting process.
Number of large claims	Exposure	Indicator for possible reinsurance problems.
Sizes of outsourcing contract	Exposure	If significant, may need more indicators from the outsourcing supplier.
Numbers of IT projects under way	Exposure	Potential integration problems and over-stretch of resource.
Percentage of business given to each supplier by volume and pound amount	Exposure	Calculated separately for each category of supplier. Can be used detect anomalies and measure exposure to supplier failure.

3.10.4 It is possible to base risk indicators on qualitative assessments. For example, managers can be asked to assess the levels of various types of risk in the areas for which they are responsible in terms of a simple numerical scale. Over time, the emerging relationships between actual loss experience and the judgement-based risk indicators can help managers to refine their estimates (BCBS, 2003). A similar technique can be used to set the ranges that are initially considered normal for risk indicators.

3.11 *Risk Indicators for MELG*

3.11.1 The risk director has considered a number of risk indicators for use in MELG. Some of these are summarised in Table 3.11.1.

3.11.2 Table 3.11.1 does not include specific indicators for computer systems risks such as viruses, security breaches and so on.

3.11.3 Many of these indicators are fairly generally applicable, and are useful at the level of individual business units or processes as well as company-wide. Others are specific to particular business processes or risks.

3.11.4 The risk director considered appropriate indicators for dominance risk. He found it difficult to see how the personality of the chief executive could be quantified in an acceptable way, and doubted whether self-assessment would be accurate. However, he hoped to introduce self-assessment indicators in a number of areas, such as the availability of management information and the complexity of reinsurance arrangements. He also planned to develop a questionnaire, for example seeking personal views about the general approach to governance, remuneration and performance management, culture, management and staff shareholdings, existence of succession plans, general atmosphere and approach to upwards and/or downwards feedback.

4. Capital Requirements — Stress and Scenario Testing

4.1 *General Approach*

4.1.1 Stress testing and scenario analysis are part of best practice in the overall management of a non-life insurance company. Stress testing and scenario analyses, being based on an analysis of the impact of unlikely, but not impossible events, enable a company to gain a better understanding of the risks that it faces under extreme conditions. Together with dynamic financial analysis (DFA — discussed in Section 7), they provide a basis for estimating capital requirements.

4.1.2 Further impetus to perform this type of analysis has recently come from the FSA (FSA, 2003b). Companies will be required at all times to maintain overall financial resources, including capital and liquidity resources, which are adequate to ensure that there is no significant risk that liabilities cannot be met as they fall due. Stress testing and scenario analysis are valuable ways of testing and demonstrating financial adequacy, particularly when capital levels are relatively high compared to that envisaged as required in most reasonable adverse scenarios. The FSA guidance states that major sources of risk must be identified, and stress and scenario tests performed for each.

4.2 *Theory*

4.2.1 *Stress testing* is the process of evaluating a number of statistically defined possibilities to determine the most damaging combination of events, and the loss that they would produce. Stress testing also answers the question of how far the risk factor must go to give negative surplus (or surplus below a certain amount) over a specified time horizon. The likelihood of the assumptions that lead to this outcome is then assessed and compared to a threshold level in order to determine whether they are significant or not.

4.2.2 *Scenario analysis* is the process of evaluating the impact of specified scenarios on the financial position of a company. The emphasis here is on specifying the scenarios and following through their implications. Scenario analysis typically refers to a wide range of parameters being varied at the same time. The scenarios could be chosen as events that are intended to have a defined probability of occurrence, e.g. a one in 100 year event. It is still not entirely clear if the present FSA guidelines about assessing overall risk tolerance apply to aggregated risks or for each risk independently in turn.

4.2.3 There are two types of events that may be considered. Historical events are often more easily understood, and are sometimes considered to be less arbitrary, while hypothetical events may provide a more thorough and systematic analysis, but anticipate risk with no historical parallel.

4.2.4 The tests should be carried out at least annually, or more often, depending on the possible impact of the risks. For example, a sudden change in the economic outlook may prompt a company to revise the parameters of some of its stress tests and scenario analyses. Stress tests may be added if a company has recently been exposed to a particular sectoral concentration.

4.4 *Case Study Application*

4.4.1 In order to carry out stress and scenario tests, MELG's risk director considered the specific circumstances of MELG. It was decided that reviewing the operational risk exposures under the categories — administration, compliance, event, fraud, governance, strategic and technology risks — would capture the dynamics of the business and give a reasonable set of realistic possible events. For each of these sources of operational risk, the risk director carried out appropriate, separate tests.

4.4.2 *Administration risk.* In order to set up stress tests and scenario analyses for administration risk, the risk director looked at the past administrative deficiencies, taking account of both the actual losses recorded in the exception reports and the results of the Delphi analysis (see ¶2.7.8). Other relevant factors include the nature and extent of centralised and decentralised functions and the segregation of duties between staff. The risk director was satisfied that there was an adequate segregation of duties between underwriting, claims and payments divisions in terms of acceptance, authorisation and payments. He was also satisfied that there was sufficient interaction between the front, middle and back offices in terms of financial control and risk management.

4.4.3 The risk director considered that the administration risks were reasonably well understood and predictable, and was able to suggest a single point estimate of the capital required to cover these risks, given the group risk committee's previously agreed risk tolerance or risk appetite.

4.4.4 *Compliance risk.* MELG's risk director considered the principal compliance risk to arise from the risk of non-adherence to legislative and internal company requirements. An investigation into compliance over the last five years found no history of non-compliance with policy and control systems, nor had there been any reported areas of non-compliance with legislation or other requirements.

4.4.5 However, there are regulatory reforms due in the next five years, and therefore the risk director felt it prudent to assume an increase in the expense ratio over this time period. Given the relatively low level of uncertainty, the risk director was again able to come up with a single point estimate of the capital required to cover these risks.

4.4.6 *Event risk.* Event risk is the risk associated with the potential impact of significant events on the company's operations. The risks are those that are directly related to the products and services offered, and not to events impacting other business risk areas, e.g. non-life insurance business, credit exposure or market risk. MELG's risk director concluded that no additional capital was required for this type of risk.

4.4.7 *Fraud risk.* In assessing fraud risk, MELG's risk director was able to use the major incident that involved fraudulent activity in relation to an external supplier (see ¶2.7.3), which resulted in a loss of £5m. After allowing for the improvements in controls that resulted from this incident, the scenario analysis produced a range of estimates for the amount of capital required to cover future fraud.

4.4.8 *Governance risk.* Governance risk is the risk that the Board and/or senior management will not perform their respective roles effectively. MELG's risk director investigated the existence and level of directors and officers insurance in place, and compared it to the known incidence of claims of this type.

4.4.9 The current level of corporate governance was considered, and an assessment made of the likelihood that its shortcomings might result in the Board and/or senior management not adequately undertaking their roles. In addition, costs of altering or strengthening the current Board structure were analysed. Given the uncertainties involved, the risk director was unable to come up with a single point estimate of the capital required, and instead used a range of estimates.

4.4.10 *Strategic risk.* Strategic risk arises from an inability to implement appropriate business plans and strategies, make decisions, allocate resources or adapt to changes in the business environment.

4.4.11 MELG's risk director assessed the prudence and appropriateness of the future business strategy in the context of the competitive and economic environment. In particular, the assumptions, forecasting and projections were assessed, considering the possibility of a fundamental market change due to higher numbers of competitors, changes in sales channels, new forms of insurance or changes in legislation. This review included whether the reinsurance programme is appropriate for the risks selected and whether it adequately takes account of the underwriting and business plans of the company in general. It was considered that the likelihood of a fundamental strategic shift was too remote to include within the scenario, given the maturity of the market in which MELG operates.

4.4.12 On the other hand, the risk director was concerned about the effect of the losses caused by the decision to move to a 70/30 personal/commercial business mix. Although he had, in the end, decided not to treat this as an operational loss (see ¶2.9.7), he thought it worthwhile to investigate its effect.

4.4.13 To determine the loss size, he first selected a time horizon over which to estimate the cumulative losses. It seemed that the business plans and strategy ought at least to be reviewable on an annual basis, but that, in this case, it might take more than a year to achieve the required correction to business mix. Hence, he estimated the effect on bottom line of having written a 70/30 mix rather than the preferred 90/10 for the third and fourth years from implementation — that is an estimate for 2003 and 2004. To do this he compared the results from the DFA model with implicit allowance for operational risk on a 70/30 mix with those on a 90/10 split.

4.4.14 *Technology risk.* MELG's risk director considered the risk of error or failure associated with the technological aspects (IT systems) of MELG's operations, including both hardware and software risk.

4.4.15 The risk director considered the past reliability and future functionality of the information systems to be adequate. However, past software projects have resulted in significant cost overruns (see ¶2.7.9), and, although there were no definite plans to replace systems or make major modifications future problems could not be ruled out.

4.4.16 Plans for business continuity management and disaster recovery are reviewed regularly and tested quarterly. There is a back-up site with full recovery capabilities. When performing the scenario analysis, the risk director allowed for the costs associated with utilising the site and the associated business interruption insurance. The risk director was able to estimate a range for the capital required to cover these risks.

4.5 *Overall Assessment*

4.5.1 After assessing each risk area individually, MELG's risk director considered the capital that was estimated to be absorbed under each scenario. He considered how many of these scenarios might reasonably occur within a period and the extent to which capital could be replaced within that period. The analysis took into account scenarios which might reasonably be linked, the difficulty with which capital might be replaced if the scenarios occurred, and the changes in strategy which might need to be adopted if the scenarios occurred.

4.5.2 Finally, the risk director estimated the range of capital that would be absorbed by the worst realistic combination of circumstances that might arise. The group risk committee noted that this was useful, but did not give a quantified probabilistic assessment, which made it difficult to compare with their agreed risk appetite.

4.5.3 In effect, he was using his best business judgement to determine how many losses might occur in a poor, but not impossibly bad, year.

4.5.4 Readers should also recall that this illustration uses only a few risk categories compared to the full range that would need examining in real life.

4.6 *Comments and Observations*

4.6.1 Stress testing and scenario analysis are very practical and easy to understand methods. They require significant judgement and experience, and may possibly need to incorporate external advice.

4.6.2 In the case of a relatively well capitalised business, these relatively simple approaches can help provide significant evidence about capital adequacy.

4.6.3 The method does not give a mathematically-based view on probabilities of different scenarios — it relies on the modeller's assessment of likelihood, based on discussion with, and the input of, experts, as appropriate.

5. Frequency and Severity Analysis (including EVT)

5.1 *General Approach*

5.1.1 The frequency and severity analysis approach is already well documented in actuarial literature (e.g. IoA *Claims Reserving Manual*). The basic principle is to use separate statistical models to generate the number of losses and the size of each loss. The parameters for the models are derived by fitting distributions to the actual historical loss data. Standard Monte Carlo techniques can then be used to simulate the number of events and a loss size for each event.

5.1.2 Distributions that are often used for the frequency include Poisson, negative binomial and binomial. Lognormal, weibull, or gamma are common choices for the severity distribution.

5.1.3 Typically, the first step is to modify the actual historical data to allow for future likely changes in claim numbers, to take account of known changes in controls and procedures. Then a number of curves from different families are fitted to the data. The criteria for choosing the curve with the best fit depend on the circumstances: for example, when considering the value of an excess of loss reinsurance contract, the modeller might be more concerned over the fit of the model for large than for small claims. Tools that can be used at this stage include standard maximum likelihood and other goodness of fit tests, such as plotting the actual and modelled distributions and considering the fit at decile or percentile points in the most relevant part of the curve.

5.1.4 Operational losses tend to have even more skew distributions than actuaries are used to, with extremely low frequency and high impact losses being very significant.

5.1.5 Extreme value theory (EVT) is a tool that has its roots in the physical sciences, and is increasingly being applied in insurance (Embrechts *et al.*, 1977). As its name suggests, it focuses on extreme values rather than on measures of central tendency, such as the mean. Traditional statistical techniques are inaccurate when estimating the values of larger losses, because of their emphasis on the area round the mean of the distribution. EVT, on the other hand, ignores the majority of the underlying loss data in order to provide better estimates in the tails of the distribution.

5.1.6 EVT can be seen as simply another family of distributions that can be fitted to either severity data or to total annual losses (combining the frequency and severity distributions into a single distribution). The basic idea is to pick a threshold for large losses, and then to use a generalised pareto distribution (GPD) to determine the severity of a loss given that it exceeds the threshold.

5.2 *Theory*

5.2.1 As a reminder, EVT uses the cumulative distribution function $1 - \lambda(1 + \xi(x - u)/\sigma)^{-1/\xi}$, where u is large, and is the threshold size above which the distribution holds, and $\lambda = \Pr(X \geqslant u)$, ξ and σ are shape and scale parameters.

5.2.2 A simple approach to parameterising the extreme value distribution starts with the determination of u, the loss size above which the extreme value distribution is assumed to be appropriate. This can be done by plotting the mean excess above the threshold against the threshold value. The point at which this graph becomes linear can be taken to be u. λ is the number of losses in excess of this threshold divided by the total number of losses.

5.2.3 The shape and scale parameters ξ and σ are then determined by maximising the log likelihood function for the extreme value distribution $(-\log\sigma - (1/\xi + 1)\sum\log(1 + \xi(x_i - u)/\sigma))$, for $i = 1$ to r, the number of observations larger than u).

5.2.4 This then defines the distribution for losses above u in size (or alternatively for losses where $\Pr(X \leqslant u) > \lambda$). For losses below u in size, normal curve fitting approaches can be used to determine a distribution, and this can be scaled so that at size u the two distributions meet smoothly.

5.3 *Case Study Applications*

5.3.1 As MELG's risk director started to model the operational losses, he realised that they fell neatly into three groups:
— claims leakage/fraud losses, with high frequency and low severity;
— system development overspend losses, with lower frequency and medium severity; and
— miscellaneous losses with low frequency and high severity.

5.3.2 The risk director decided to reflect these differing characteristics in the model. By modelling the three sets of losses separately the homogeneity of the losses was improved.

5.3.3 Neither the claims leakage nor systems overspend losses showed any unusual characteristics, so standard statistical curve fitting was deemed to be appropriate.

5.3.4 The risk director decided to model the absolute number of losses rather than the frequency, as there were no good exposure data available (that is no suitable information to form a denominator for calculating frequencies) for more than the last year or two. The data used were as in Tables 2.9.9 and 2.9.10. Details of the fitted distributions and parameters are shown in Appendix C.

5.3.5 The set of low frequency/high severity losses required more consideration on two grounds: first, whether all of them should be included; and second, how to model them. As discussed in ¶2.9.7, the losses caused by the imposed decision to move to a 70/30 personal/commercial business mix were, in the end, omitted.

5.3.6 The risk director decided to model the loss numbers using the same Poisson as for the other two groups of losses. However, he noted that this might not be entirely appropriate, as the mean and variance of the actual annual numbers of losses were rather different. On the other hand, he reasoned that a start had to be made somewhere.

5.3.7 In order to model the severity, the risk director decided to consider three standard distributions and the extreme value distribution to begin with. MELG had not yet acquired proprietary curve fitting software, so the risk director chose distributions that are simple to apply using Excel. Three distributions that are commonly used to model insurance losses and that meet this criterion are the lognormal, weibull and gamma distributions. The parameters were estimated using the data, and then the fit examined by graphing the cumulative distributions for the actual and model data and looking at the Q-Q plots of actual versus model for each distribution. A chi-squared test was also used to look at the appropriateness of the three alternatives.

5.3.8 An extreme value distribution was then fitted to the set of low frequency/high severity losses. This was done in a fairly pragmatic fashion. A plot of mean excess losses was used to determine an appropriate threshold

Table 5.4.2. Summary expected losses at various percentile points

	Poisson/ EVT	Poisson/ lognormal	Poisson/ weibull	Poisson/ gamma
Expected annual loss (£m)	100.6	52.8	44.1	44.8
99.0th percentile	612.1	253.2	181.6	183.5
99.6th percentile	722.4	311.0	209.0	208.4
99.8th percentile	855.4	351.6	221.1	224.7
99.9th percentile	911.1	429.3	237.4	238.5

value for the distribution — that is the loss size (or its corresponding cumulative probability) above which the extreme value distribution applies. Then maximum likelihood was used to find the values of the two remaining parameters. The graph is shown in Appendix C.

5.3.9 The risk director decided to use EVT for the loss size distribution for the low frequency high severity losses. He then used the frequency and severity distributions for all three groups to model annual losses stochastically for a large number of simulations using @Risk.

5.4 *Results*

5.4.1 The risk director found that visual inspection of the graphs suggested that the weibull or lognormal better represented the loss experience to date than the gamma, but no more than that. A simple chi-squared test suggested that the lognormal was the better fit.

5.4.2 Table 5.4.2 shows the expected loss and a selection of the higher percentile points for EVT and the standard distributions.

5.5 *Comments and Observations*

5.5.1 The main observation is that the values in the table vary considerably. The variation is largely a result of the differing shapes of the tails of the distributions, together with the small number of large losses. There is less variability in the expected values, which is reasonable, given the larger volume of data influencing their levels. The higher percentiles, which have larger variability, are very important for the purposes of determining the levels of capital required.

5.5.2 Although, in this case, the risk director felt that the choice of u, the threshold loss size, was reasonably obvious from the mean excess plot, it was clear that this might not always be true. The smaller the dataset used, the more subjective the choice of u could become, as any linear relationship becomes less obvious and more a matter of interpretation.

5.5.3 The risk director used Excel to perform all the calculations required. This was a little time consuming to set up initially, although thereafter could be easily replicated. He decided to investigate statistical software packages so that he could do this more efficiently and more robustly.

5.5.4 The risk director was interested to see that the extreme value approach actually gave less extreme outcomes at the less extreme percentiles.

5.5.5 Overall, the risk director recognised that the analysis was somewhat simplistic and failed to take into account a number of important factors.

5.5.6 The decision of what losses to include failed to allow for the fact that the causes of past losses may have been partly or wholly controlled through changes in internal processes and procedures. Hence, it might be argued that these losses would not be repeated in the future, and so should not be included in the set of losses to which a model is to be fitted.

5.5.7 On the other hand, it is also likely that in future losses might occur as a result of hitherto unencountered or unimagined underlying causes, let alone the almost inevitable consequences of future strategic decisions. For example, there might be future losses due to a brand new process using technology that is not currently available. It is at least possible that these future losses could be of broadly similar size to the losses that would be omitted due to better controls. Given the uncertainties involved, the risk director felt that the approach of simply including all the known losses was a reasonable one.

5.5.8 There may also be types of losses that are already known about or have been experienced by others in the industry, but that a particular company has not yet experienced. For instance, MELG has suffered no cases of physical damage losses (e.g. fire or flood damage to the company's offices). One approach to this problem is to use external data, or seek the opinion of external experts on the frequency and severity distributions of such losses, and ensure that the fitted model takes this into account. In the case of external data, an important consideration is whether the organisation suffering the loss is of a comparable size and type to the one for which the modelling is being performed, and whether any adjustments are required to reflect size or operational differentials. In practice, such adjustments are extremely difficult: how would external loss data based on the experience of banks be adjusted to be appropriate to a medium-sized general insurer, for instance?

5.5.9 In addition, it may well be that some of the past losses would, if they happened today, be of significantly different size. This could be the result of, for example, claims inflation, expense inflation or changes in volumes of business. In such circumstances, it would seem appropriate to adjust the historic losses to allow for these effects so that they reflect the position in the period of projection.

5.5.10 It therefore becomes important to develop appropriate measure(s) of exposure for each type of loss. This could vary significantly — for losses caused by a problem with a particular transactional process, it might ideally be the number of such transactions. For losses caused by an error in the pricing of a particular product, it might be the number of policies or the premium income for the product. For losses due to theft of moveable equipment, it might be the number of units and their value. Note that the measure of exposure for frequency and for severity may well be different. For example, in the case of employment practice losses, frequency may be related to the number of employees, but severity to average annual salary or average court/tribunal awards. The next stage is to consider how the value of the exposure measure has changed since the loss was incurred, and adjust the historic loss to the same extent.

5.5.11 When modelling operational risk losses, as with any situation where data are scarce, the scope for parameter error is relatively high. It will be instructive to look at the standard error for the parameter and consider the impact of changing the parameters by, say, one standard error, on the outcome. Where capital requirements are set to reflect a relatively high level of risk aversion, this could make a very significant difference to the amount of capital that a model might suggest should be set aside in respect of operational risk.

5.5.12 For the same reasons the choice of distribution is unlikely to be clear cut, and so looking at the effects of changing the distribution would also be instructive.

5.5.13 In MELG, the low frequency/high severity losses cover asset failures, loss of key personnel, supplier fraud, failure to check contract wordings and communication failure, expense overruns and poor project evaluation and management. There are no identified examples of physical damage to property, employment practice problems, health and safety failures, mis-pricing or under-reserving. After discussion, it appeared to the risk director that there were few obvious exposure measures that might shed light on whether the historic loss amounts or numbers should be adjusted to reflect the organisation's current position. Hence, the risk director decided to model the losses unadjusted, although he met some opposition to his inclusion of the loan default loss.

5.5.14 However, there are very few very large events and some clustering of loss sizes in the £20m to £50m range. The risk director therefore sought views from a management consultancy on their perceptions of MELG's potential exposure to very large losses and to losses of types not yet reflected in the internal data — in particular to mispricing, under-reserving and physical damage on a scale likely to disrupt business — given their knowledge of the financial services market. He incorporated their views into the tail of the severity and frequency distributions by ensuring that the cumulative distributions passed through certain points.

5.5.15 The risk director was at least comforted that some traditional actuarial methods were found to be readily applicable to modelling operational risk losses.

6. Causal Modelling and Bayesian Methods

6.1 *General Approach*

6.1.1 In this section we discuss causal risk mapping as a technique for analysing and understanding risks. The technique can be extended to give a quantitative assessment of risk by making use of Bayesian probability theory. The resulting Bayesian networks can be used to gauge the effect of possible risk control strategies, as well as to estimate risk probabilities. They are a useful tool during the understanding and decision stages of the risk management control cycle.

6.1.2 In this section we have illustrated a simple example of a Bayesian causal network. We then illustrate how this technique may be applied in a simple way to the case study. See our previous paper (GIRO, 2003) and the texts that have been written on the subject (such as King, 2001) for more information on the background and theory of these models.

6.2 *Theory*

6.2.1 Bayesian networks are useful when modelling situations in which causality plays a role, but where our understanding is incomplete (Charniak, 1991). Probabilistic reasoning is a powerful tool under these circumstances.

6.2.2 A simple example, based on one taken from Pearl (1988), illustrates the approach. Normally, the sound of a burglar alarm going off means that there has been a burglary. However, it might also be triggered by an earthquake. If there is an earthquake, one may hear a radio announcement to the effect that an earthquake has occurred. We can use conditional probabilities to model the situation as follows (assuming one lives in a high crime neighbourhood in California):

— There is a 95% chance that an attempted burglary will trigger the alarm: P(alarm|burglary) = 0.95.
— If there is an earthquake, there is a 20% chance that the alarm will be triggered: P(alarm|earthquake) = 0.20.
— If there is an earthquake, there is a 40% chance that one will hear an announcement on the news: P(announcement|earthquake) = 0.40.
— There is a 1% chance that a given house will be burgled on a given night: P(burglary) = 0.01.
— There is a 1% chance that there will be an earthquake on a given night: P(earthquake) = 0.01.

6.2.3 Figure 6.2.3 shows that the probability of hearing the burglar alarm on any given night is 1.15%.

6.2.4 We can use the same network to analyse the situation in the case that one actually hears the burglar alarm. Figure 6.2.4 shows that if the burglar alarm is heard, but no radio announcement, then the probability that there was a burglary is 88%.

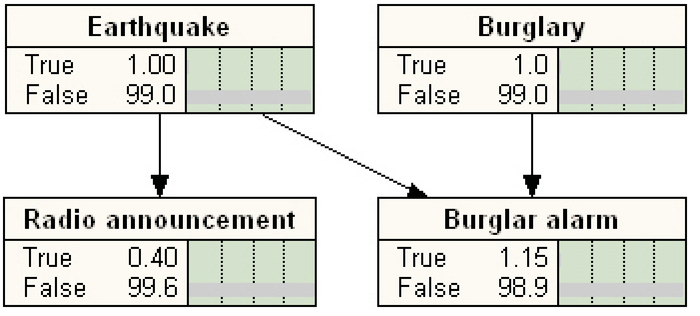

Figure 6.2.3. Probability of hearing the burglar alarm

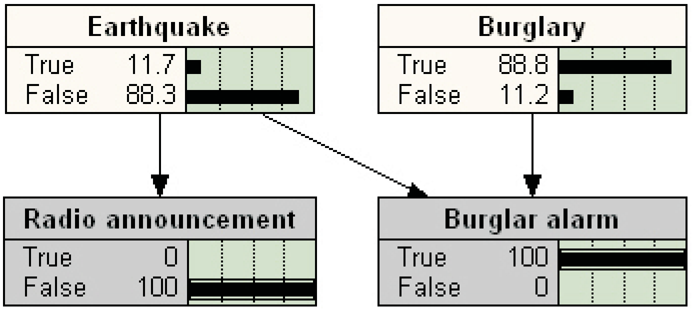

Figure 6.2.4. Probability of a burglary if the alarm is heard, but no radio announcement

6.2.5 On the other hand, if both the alarm and a radio announcement of an earthquake are heard, the probability of a burglary falls to under 5%, as shown in Figure 6.2.5.

6.2.6 The network provides a clear visual representation of the connections, and there are reasonably efficient algorithms for performing the probabilistic inference (Pearl, 1988; Charniak, 1991; Netica, 1997).

6.2.7 The prior and conditional probabilities that are used in the network need not be very precise in order for useful information to be gained. Moreover, they can be adjusted as more experience of the risks and the relationships of their causes and effects is acquired. In this way the model can 'learn' from the data that are collected and fed into it in a Bayesian fashion. The model starts with some initial beliefs about a process with little data and ends up reflecting the reality of the information that is collected over time.

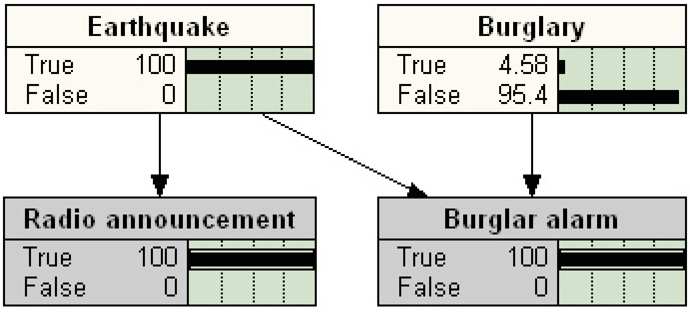

Figure 6.2.5. Probability of a burglary if the alarm is heard and there is a radio announcement

6.3 *Case Study Application*

6.3.1 The first step in applying this methodology is to set out a risk map of the process in question. Having decided to use Bayesian networks to help understand MELG's overall risk vulnerability, MELG's risk director started with an enterprise wide risk map set out by McDonnell (McDonnell, 2002), shown in Figure 6.3.1.

6.3.2 In this high level model policyholder harm results from financial outcomes including underwriting or other revenue losses, balance sheet losses

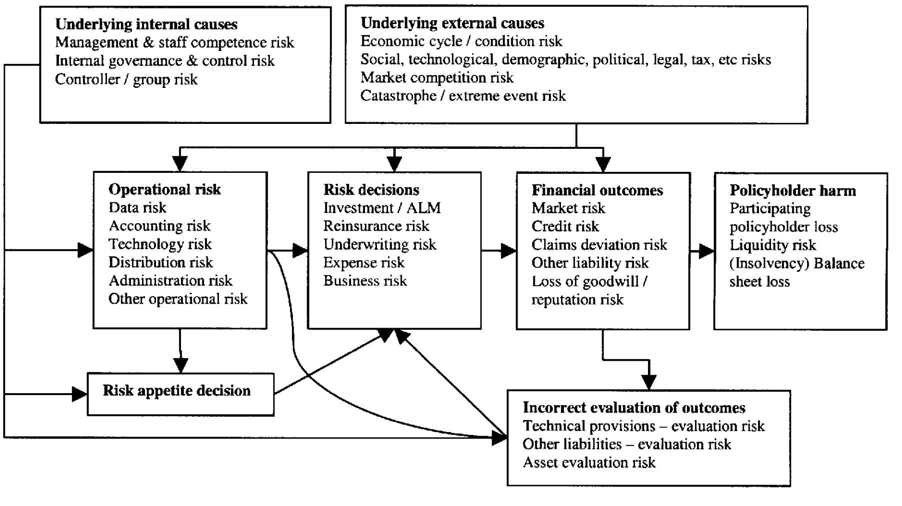

Figure 6.3.1. Enterprise wide risk map

or a loss of reputation or goodwill. Such losses are brought about as the results of risk decisions, which may relate to underwriting, expenses, reinsurance, investments or more general business risk. For operational risk, incorrect decisions are attributable to inadequate or failed internal processes, people or systems. Behind the failed processes, risk decisions and financial outcomes are underlying or trigger causes, which may be internal (management, governance or ownership related) or external (wider changes, as well as event or market specific changes).

6.3.3 It is worth noting that this cause-effect risk map has an adaptive feedback control loop, from risk decisions to financial outcomes to incorrect evaluation of financial outcomes, and back to risk decisions. This requires some iteration in the modelling.

6.3.4 An example of using a Bayesian causal approach at this enterprise level is given in our GIRO paper (GIRO, 2003). For the purposes of this paper, the risk director has decided to drill down further and use risk mapping by cause and effect to investigate what can be learnt about the risks faced by the company from the known losses.

6.3.5 The purpose of this form of risk mapping is to document and make explicit the causal chain that has brought about a particular risk outcome, and the impact of the outcome on the business.

6.3.6 The risk director has constructed a causal risk map for each of the losses experienced by MELG. The first is the loss incurred as a result of the launch of direct writing and is displayed in Figure 6.3.8. Similar risk maps for the remaining losses in the case study are shown in Appendix D.

6.3.7 The cost incurred in launching the direct writing operation was in the region of £70m, partly due to expense overruns and partly to lower than expected business growth. The risk decisions involved were faulty because of

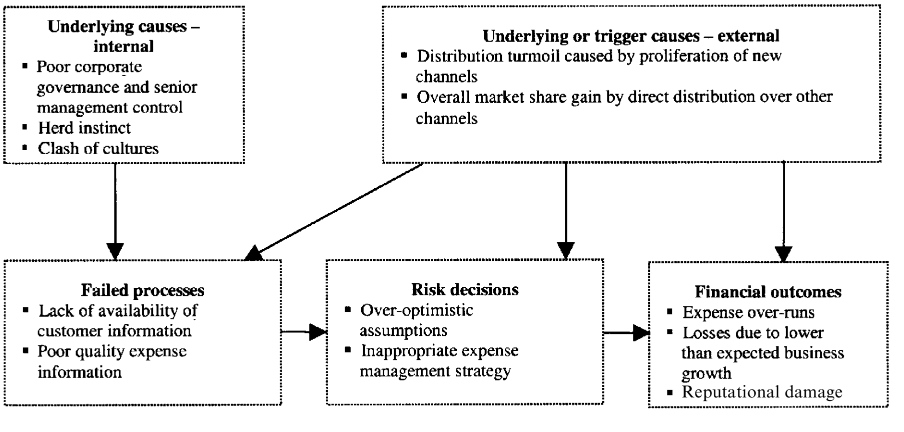

Figure 6.3.8. Risk map

inadequate information and over-optimistic assumptions. Process failures caused poor availability of information on customers and expenses. External drivers included the turmoil in general insurance distribution generally, and particularly the gain in overall market share by direct distribution against other channels. Internal drivers included management pursuing a 'me-too' strategy and also the clash of cultures between the direct and the traditional areas of the business.

6.3.8 The resulting risk map is shown in Figure 6.3.8.

6.4 *Case Study Results*

6.4.1 MELG's risk director has converted this risk map into a Bayesian network appropriate for a causal model. The loss is applied and interpreted into the network as follows:

— *failed processes and internal drivers*: interpreted as a 'weak' score for 'failed internal processes' and a bias towards 'weak' for internal 'governance/control';
— *faulty risk decisions*: interpreted as a stronger relationship between 'failed internal processes' and the risk decision nodes of 'investment/ALM risk', 'reinsurance risk', 'insurance underwriting', 'expense risk' and 'business risk', which biases these nodes towards 'weak'; and
— *external drivers*: scenarios were run with an unbiased view of the external causes as well as with 'weak' external drivers ('weak' interpreted here as external drivers that generate a disadvantageous situation for the company).

6.4.2 The risk director then investigated how different levels of 'outcome evaluation' impacted the outcome of the model. The outcome is given as a measure of 'policyholder harm', whereby 'strong' is interpreted as little or no negative impact on policyholders, and 'disaster' is interpreted as significant negative impact on policyholders.

6.4.3 An example of the simple Bayesian model used is shown in Figure 6.4.3, and the results of the various scenarios are summarised in Table 6.4.3.

6.4.4 For the interested reader, the other Bayesian network model images representing the scenarios in Table 6.4.3 can be found in Appendix D.

6.4.5 We might question, from the large number of operational incidents and the varied misfortunes that have beset MELG in recent years, whether the senior management team was incompetent rather than unlucky. There were clearly also corporate governance and group controller issues and concerns. It does not seem unreasonable to conclude that the initial belief network should show a 'weak' score for failed internal processes.

6.4.6 Nevertheless, it can be seen that 'weak' failed internal processes need not lead to a terminal prognosis for MELG plc. Much depends on the 'downstream' risk enterprise wide management issues, such as the 'outcome

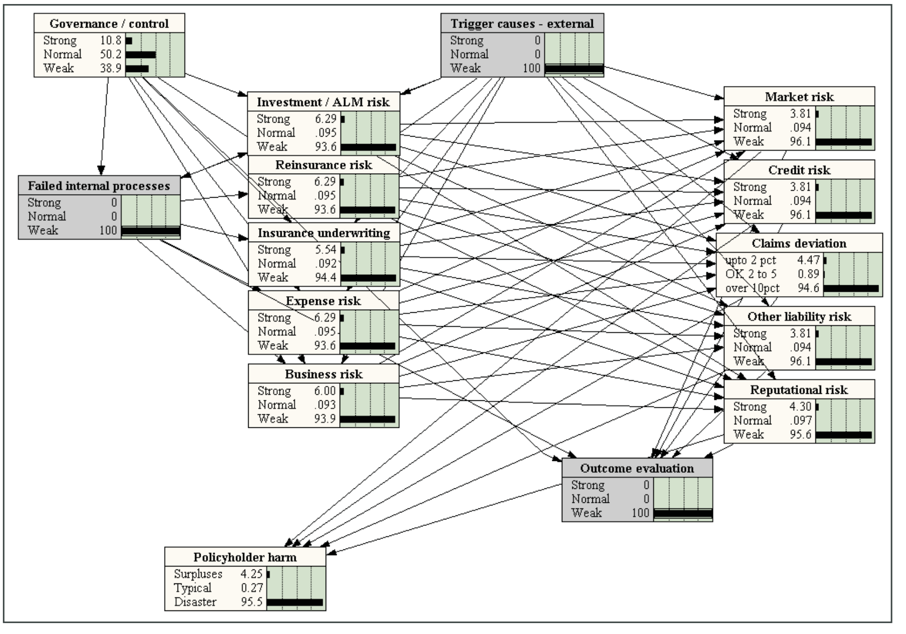

Figure 6.4.3. Simple Bayesian model

Table 6.4.3. Results from simple Bayesian model

Failed internal processes	External trigger causes	Outcome evaluation	Individual risks	Prob (policyholder harm = disaster)
Weak	–	–	–	68.9%
Weak	Weak	–	–	92.0%
Weak	Strong	–	–	43.8%
Weak	–	Weak	–	83.6%
Weak	–	Strong	–	35.6%
Weak	Weak	Weak	–	95.5%
Weak	–	–	Weak	99.8%

Note: '–' indicates default value

evaluation' score, which represents the risk that financial outcomes are incorrectly evaluated.

6.4.7 The financial prognosis for MELG plc is less severe if it can be shown to have 'strong' management competencies in respect of 'outcome evaluation'. At least the senior management team would then be able to read the early warning signals of the impending 'policyholder harm', rather than be confused by the noise from a potentially inadequate ‘outcome evaluation’ process.

6.4.8 Indeed, it can be seen from the results that improving the ‘outcome evaluation’ process from a ‘weak’ to a ‘strong’ score reduces the probability of disastrous policyholder harm from 83.6% to 35.6%. It may be that this is the first area where management should direct its attention in order to reduce the operational risk exposure of the company.

6.4.9 The overall conclusion of MELG’s risk director was that the upstream issues of corporate governance, a resilient senior management team and sound internal business practices, processes and controls were necessary to mitigate the potential for downstream operational loss incidents. This ideal situation may take some time to achieve if it is not already working.

6.4.10 In the short term, however, the risk director could see that improvements to MELG’s processes for handling and evaluating incidents that do occur would mitigate significantly the potential loss from these incidents. In this way, the risk director could start taking steps to ensure that the absence of sound upstream practices does not lead to an accident prone senior management team and the consequent risk of policyholder harm.

6.5 *Comments and Observations*

6.5.1 The causal risk maps provide a good structure for analysing the known losses. First, they make the distinction between risk events and risk outcomes clear. Second, they help to clarify the management decisions that resulted in an adverse outcome. Management decisions may be driven by the failure of processes, systems or people, by external events or by internal factors or, more probably, by a combination of all three. The risk maps thus make it evident that operational losses involve complex chains of cause and effect.

6.5.2 Causal risk maps can also be used to analyse potential losses. The analysis of both potential and actual losses helps to make the underlying causes of operational risk clear, and assists in deciding what control or mitigation steps to take.

6.5.3 Bayesian networks, in conjunction with causal risk mapping, can be a valuable tool in the risk director’s armoury. Their calibration, however, can be tricky, and requires a heavy investment of resources.

6.5.4 The most productive way of using Bayesian networks is in conjunction with risk indicators. The risk indicators can be used to help calibrate the model, which is used to aid the deeper understanding of the risks. In turn, the model can help to suggest effective risk indicators for ongoing risk monitoring.

6.5.5 Regarding the work performed, the next stage is to gather some more data to put into the model and revise our initial beliefs about the system in the light of this information. Intuitively, this model, with explicit relationships and the ability to take initial beliefs and revise them in the light of experience, is attractive for modelling operational risk. We need to do some more work in this area to see the true potential benefits.

7. DFA and Overall Risk Modelling

7.1 There are two methods of allowing for operational risk in a dynamic financial analysis (DFA) model. The first method is to construct a model using the actual financials, incorporating all the operational loss events. Operational risk is included implicitly in this method. The second method is to remove all the operational risk losses from the financial history and construct a DFA model that models everything except operational risk. The operational losses can then be modelled separately (maybe using similar methods to those described in Section 5), and added back to the model, which then allows for operational risk explicitly.

7.2 We suggest that, the second approach, explicitly modelling operational risk, is preferred, and this is illustrated below.

7.3 *General Approach*

7.3.1 The first stage of the modelling exercise is to construct a DFA model of MELG plc using its actual results, which implicitly incorporate all past operational risk loss events. As the focus of this paper is about operational risk, we do not describe the DFA technique in any detail. Readers may refer to various Casualty Actuarial Society papers (www.cascat.org/research/dfa) or a recent paper from Converium Re (2003). The model and software tool used for the illustrations below was similar to that used in producing a paper entitled 'Calibration of the general insurance risk based capital model' for the FSA, dated 25 July 2003.

7.3.2 The next stage is to consider which operational risk events will be modelled explicitly. This will require judgement about the likely modelled frequency/impact of different loss categories on the projected accounts. The historic data are then recast, with these operational risk events removed.

7.3.3 A second DFA model is then produced which effectively considers how the company would look if it could manage itself so that the chance of such events (i.e. those explicitly modelled) was zero (assuming, for the sake of clarity, that there is no need to add in any of the probable costs of management/mitigation). Even using this naïve assumption gives an interesting insight into the quantum and variance resulting from the selected operational risk events.

7.3.4 The selected operational risk losses are then modelled separately using probability distributions and parameters that reflect past data, including wider market insights if relevant. These are then combined into the second model, to produce one where the explicit effect of the selected loss events can be seen.

7.3.5 In effect, we now have one set of selected distributions and parameters feeding two different financial models, so that the differences can be studied in a meaningful way. A further task is to consider whether the assumptions based on past data are appropriate for modelling the future. It may be that the risk indicators and recent changes to processes or systems of control suggest either a degradation or improvement in likely future experience. The quantified impact of revised assumptions can be explored under different scenarios, and, in effect, the implicit and explicit model outcomes can then be compared.

7.3.6 The modelling can be built to explicitly allow for forms of management/mitigation other than solvency capital.

7.3.7 This modelling approach integrates all risks, and is a useful tool for assessing the total impact of credit, market, liquidity, insurance and group risk, as well as operational risk.

7.4 *General Theory (More Detail about the DFA Models)*

7.4.1 Computer modelling techniques have resulted in a wide range of simulation methods, based on Monte-Carlo (time series analysis or use of random numbers to generate a number of outcomes that simulate assumed underlying probability distributions). When modelling operational losses, the selection of assumed distributions for event frequency/severity will depend on the nature of the loss category. It may be appropriate to consider whether the loss category is, in effect, an attritional loss (high frequency/relatively small variation), or moderate frequency/medium sized (either skewed or symmetrical about the mean) or low frequency/high impact with extreme skewness.

7.4.2 The illustrated loss events modelled were the fraud issues (affecting claims), the systems project issues and aspects of major decisions (affecting claims and expenses), and the forced strategic asset mix matter (affecting investment income and asset values). As already discussed (see ¶2.9.7), it was decided not to include the impact of the strategic risk resulting from the determination to grow commercial lines against the will of the U.K. management team.

7.4.3 A further consideration is whether operational loss events should be considered to be independent or correlated with other losses. For example, should external economic assumptions affect fraud levels as well as asset values, claims frequency and/or severity and expenses? As another example, should management change be modelled as a driver of insurance result volatility as well as of large operational losses following strategic decisions? DFA techniques enable the modeller to establish driver assumptions and correlations.

7.4.4 The underlying business assumptions in the illustration are based on the combined FSA return data of the major household and employers liability companies, as discussed in Section 2 (the case study). A proprietary market consistent time series investment model is used.

7.4.5 We hope that readers will focus on the underlying approach and type of analyses rather than on the details and results of the model.

7.4.6 The DFA approach makes combining different risk distributions relatively easy. Although our illustrations assume no correlations, the approach also allows the modeller to experiment with correlation coefficients until the modelled outcomes look fully realistic. It also facilitates investigating linkages — when one thing goes wrong, does everything else go wrong at the same time?

7.4.7 Once parameterisation and model construction was complete, 1,000 simulations were carried out.

7.5 *Case Study — Applications and Results*

7.5.1 The explicitly modelled operational risk losses consisted of a set of high frequency/low severity claims leakage/fraud losses, a set of lower frequency/medium severity system development overspend losses and a set of more disparate low frequency/high severity losses. We reflected the different characteristics of these events in our model using Poisson distributions for frequency, and normal, gamma and pareto for amounts — in order to improve the model fit for roughly homogenous groupings of losses. Appendix E shows summary results.

7.5.2 As indicated, we appreciate that the exclusion of some of the latter group of losses (as they are judged strategic rather than operational) may be open to discussion. The risk director cannot ignore such events, and has to make a judgement about how to treat them, as they are both real and have a material impact.

7.5.3 For ease, we also assumed that the modelled events were independent and uncorrelated with other risks.

7.5.4 In practice there would be additional considerations around the set of losses being modelled and the appropriateness of their inclusion. It may be that the causes of these past losses have been mitigated partly or wholly through changes in internal processes and procedures. Hence, it might be argued that these losses would not be repeated in the future, and so should not be included in the set of losses to which a model is to be fitted.

7.5.5 On the other hand, it is also likely that in future losses with similar statistical characteristics might occur as a result of rather different underlying causes — perhaps causes not even contemplated or possible at the moment — but which may well be of broadly similar sizes to those losses from the past now felt unlikely to be repeated; for example, losses as the result of a brand new process using technology that is not currently available. This may be a reason for not discounting losses where the causes have been mitigated. In effect, we have taken this approach for the case study.

7.5.6 Many other considerations are similar to those already discussed in ¶¶5.5.8 to 5.5.14, and not repeated here.

7.5.7 The risk director's first observation was that the base case mean projection was more cautious than the management's deterministic corporate plan. This would require more discussion to determine whether the model assumptions, based on historic performance, could justifiably be changed to bring them in line with the corporate plan. On the other hand, it was possible that the management assumptions might prove unrealistic — over optimistic planning being another form of operational risk, and for the time being the risk director decided to use his projections.

7.5.8 To compare the models and scenarios various indicators are used — the chance of ruin in five years, various other percentile solvency levels in five years and the difference in capital required between scenarios based on the year one (2003) ruin probability at the 99.5 percentile point, as shown in Table 7.5.8.

7.5.9 The risk director observed that using the implicit approach led to a model where the starting capital (£857m or 50.6% solvency ratio) rose to a mean level of £1.86bn or 72.5%, but also gave approximately a 5% chance of insolvency by the end of year five (2007). He found that the company required £950m to reduce the chance of insolvency within five years to 2.5%. He found it difficult to interpret this. He also calculated that a starting capital of £450m would be sufficient to meet the 99.5% requirement of remaining solvent over year one (2003).

7.5.10 He recognised that these models incorporated all modelled forms of risk, including insurance and market risks. He decided to concentrate on the differences between scenarios in order to better understand operational risk.

7.5.11 The scenario where operational risk was eliminated led to a mean level of net assets at the end of year five of £2.1bn or 82.6% solvency ratio, with roughly a 1.5% chance of insolvency by the end of year five. This encouraged him to see that operational risk control, whilst not necessarily as important as insurance or market risk, was significant, and that its proper management could make a difference. The starting capital to meet the 99.5% chance of remaining solvent in year one (2003) fell to £370m.

Table 7.5.8. Illustrative figures to accompany ¶7.5.8

	2007 mean solvency ratio %	2007 median solvency ratio %	five percentile solvency ratio end 2007 %	2.5 percentile solvency ratio end 2007 %	Probability that net assets >0 over five years	Capital to achieve year one ruin probability of 0.5%
Implicit OR	72.5	77.7	0.5	−20	95%	£450m
No OR	82.6	84.2	20.4	1	98.5%	£370m
Explicit OR	79.2	82.7	19.1	5	98%	£440m
OR with improved procedures	81.4	85.5	21.7	10	99%	£380m

7.5.12 He then looked at the model including operational risk on an explicit basis. This showed a mean level of net assets at the end of year five of £2.03bn or 79.2% solvency, with marginally less than a 2% chance of insolvency. The required capital to meet the year one 99.5% criteria was £440m, roughly in line with the implicit model. This showed that, while the magnitude of outcome was similar to that in the implicit model, the effect of assuming that operational losses were not correlated with underwriting or market movements reduced the chance of ruin.

7.5.13 His final scenario assumed that systems of control and other changes reduced the chance of large loss events by one third — this produced calculated outcomes nearer the 'no operational loss' ones (e.g. the projected mean net assets of £2.08bn, 81.4% solvency and only 1% chance of ruin, the capital required to meet the year one 99.5% level was reduced to £380m, and the chance of insolvency in five years was less, and he considered that this was strong enough evidence to drive home the need for improved systems of control around executive decision taking. (Note the 1% chance of ruin over five years is less than that modelled with no operational risk — this apparent inconsistency would need further investigation, bearing in mind that it is dependent on the very small number of adverse scenarios produced with only 1,000 runs.)

7.6 *Comments and Observations*

7.6.1 The approach enables the modeller to obtain an overview of the consequences of combining all loss categories — so called enterprise risk, and an understanding of the probability distribution of outcomes. It is clearly highly dependant on the quality of available data and modelling assumptions.

7.6.2 Many points apply to all DFA models and all modelled risk categories.

7.6.3 Specifically, the DFA model approach can be used to explore the quantifiable effects of improving the control or mitigation of certain operational risks on items such as the probability of ruin in a given (e.g. one or five-year) timescale and the resulting change in capital requirement. This, along with estimates of the associated costs, can be used to determine which of a number of proposed mitigation or control improvements is the most cost effective, and hence to prioritise the order in which they are tackled.

7.6.4 The model can also be used to understand the extent to which the possible extreme outcomes are more severe, using explicit modelling of large loss events (as once in a while a much larger separate loss occurs than implicit modelling would identify) and which event types are contributing to this most.

7.6.5 It can be used to explore features such as:

— quantifying the probability of ruin in a given (e.g. one or five-year) timescale;

— quantifying the reduced capital requirement due to diversification benefit;
— understanding whether the possible extreme outcomes are poorer with explicit modelling of large loss events (as, once in a while, a much larger separate loss occurs than implicit modelling would identify); and
— the effect of management action, or assumed improvements in operational controls or strategic decision taking processes in so far as they affect operational losses.

7.6.6 One issue is that the relative effect of explicitly modelling operational risk compared to other risks appears small — is it worth the effort? The response to this is that any modelling repays the thought given to it, and if the underlying cause of loss is operational, this modelling can get more focus into what is going on, and improve management or stakeholder value creation.

7.6.7 The apparent differences when comparing this modelled approach with the calculations in Section 5 need further consideration. In this illustration different assumptions and parameters have been used, and the results are not directly comparable. In particular, the DFA model uses a pareto distribution for the amount of large losses as opposed to the EVT generalised pareto.

7.6.8 The choice and fit of model (distribution/parameter) can be tested fairly easily, and this of itself can help improve understanding. Of course, the whole approach depends on the availability of suitable data.

7.6.9 We feel that the approach can be tailored to reflect beliefs about underlying business decisions. Admittedly this means a degree of subjectivity in the work, but then, perhaps, risk management is as much an art as a science.

8. Pitfalls and Consideration of Soft Issues

Does the Organisation have the Ability to Admit Mistakes?

8.1 The focus of this paper up until this point has been on those aspects of operational risk that lend themselves to being readily measured. However, as our discussion of risk mapping in Section 6 illustrated, there are other aspects that are not so easy to quantify and hence to model. These are sometimes referred to as 'soft' issues. In this section we consider the nature of soft issues and how they might be measured. We highlight the importance of cultural factors, and look at an approach to measuring cultural risk. We examine people risk and how it interacts with other risks. Finally, we emphasise the complexity of soft risks, and use our case study to relate them back to our earlier discussion of risk indicators.

8.2 The FSA quotes the Basel Committee on Banking Supervision, who define operational risk as: "the risk of loss resulting from inadequate or failed internal processes, people and systems, or from external events." One possible definition of soft issues is the people element of this definition. Consultation Paper 142 says:

> "The way in which a firm manages its employees can be a major source of operational risk. Poorly trained or overworked employees may inadvertently expose a firm to operational risk (for example by processing errors). In addition, a firm may find the availability of its employees, or its ability to replace them, can influence its ability to recover from interruptions to the continuity of its operations."

8.3 Operational risk has a different application for each company, depending upon its own particular circumstances. The FSA's draft guidance suggests:

> "A firm should try to understand the types of operational risk that are relevant to its particular circumstances *and* the impact that these risks may have on the incidence of financial crime, the fair treatment of its customers and its own solvency. This might include, but is not limited to, the following issues:
> — The inappropriate management of a firm's people is an important source of operational risk (people refers to the employees of a firm and all the other human resources that are involved in its operations);
> — Both IT and manual systems and their related processes are a source of operational risk;
> — Operational losses may occur as a direct or indirect result of operational risk events;
> — Operational risk events may have immediate tangible effects that can be easily quantified (e.g. monetary) and intangible and possibly delayed effects that cannot be easily quantified (e.g. reputational damage);
> — The extent to which outsourced processes, people and systems remain a source of operational risk;
> — Which external events represent sources of operational risk."

8.4 The accuracy of risk measurement methods depends on the risk model and data availability. Risk models require a thorough understanding of recurrent risk patterns, and their appropriateness is inherently linked to data availability and thus the occurrence of events. Incidents help provide better understanding of underlying risk structures and also provide the basis for statistical testing of risk models. Furthermore, the accuracy of risk models depends upon the measurability of outcomes and thus goes hand in hand with sound definition and understanding of effects.

8.5 Operational risk encompasses events with very different frequencies and possible patterns of occurrence and severities. It has been suggested that, as a first step in determining the applicability of statistical analysis, the potential incidents should be categorised into a frequency/severity matrix based on experience and expert opinion (Muermann & Oktem, 2002). See Figure 8.5.

8.6 The highest attention will obviously be paid to the high frequency/high severity risks, which threaten the very existence of the operation.

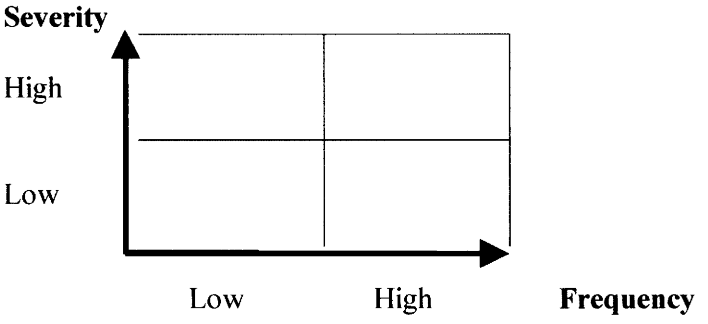

Figure 8.5. Frequency/severity matrix

Relatively little attention will be paid to low frequency/low severity risk risks. A lot of effort is often spent on the low frequency/high severity events, but, by definition, these have very few data points and the estimation of probabilities and loss distributions thus produce highly unreliable results. Other approaches are therefore needed.

8.7 By contrast, high frequency/low severity events hold out the possibility of creating large databases to which statistical analysis can be accurately applied. Historical data, if based on a thorough definition of outcomes related to operational losses, can be used to estimate the loss distribution, i.e. the probabilities of such events and subsequent losses within certain time periods. However, because we are still in the early stages of the evolution of operational risk management in the industry, these databases are not yet available, and will take a period of years to build up. In the meantime, we are compelled to use more crude and subjective methods.

8.8 This approach is advocated by the FSA, who says in Consultation Paper 142 (FSA, 2002):

— "A key issue is operational risk measurement. Due to both data limitations and lack of high-powered analysis tools, a number of operational risks cannot be measured accurately in a quantitative manner at the present time. So we use the term risk assessment in place of measurement, to encompass more qualitative processes, including for example the scoring of risks as 'high', 'medium' and 'low'. However, we would still encourage firms to collect data on their operational risks and to use measurement tools where this is possible and appropriate. We believe that using a combination of both quantitative and qualitative tools is the best approach to understanding the significance of a firm's operational risks."

8.9 The nature of soft issues is such that they are difficult to make explicit. They include factors such as morale and organisational culture, and other factors which impact on culture such as top leadership values and behaviour, communication and performance orientation. A recent British Bankers Association survey (BBA, 2002) suggests that there are a number of factors that reflect or influence the company's culture, including the style of decision making, the level of formal processes and the attributes of the core processes. All of the components are important, and they complement one another. The BBA suggests an enterprise wide operational risk framework that pulls the pieces into an integrated whole:

— *Strategy*: risk management starts with the overall strategies and objectives of the organisation and the goals for the individual business units, products or managers, followed by identification of the associated inherent risks in the strategy and objectives.
— *Risk policies*: strategy is complemented by operational risk management policies, which are a formal communication to the organisation as a whole on the approach to, and importance of, operational risk management.
— *Risk management processes*: these will encompass controls, assessment, measurement and reporting.
— *Risk mitigation*: specific controls or programmes designed to reduce the exposure, frequency or severity of an event or the impact of an event or eliminate or transfer an element of operational risk.
— *Operations management*: the day-to-day processes, both front office and back office, are involved in doing business.

Figure 8.9. Enterprise wide operational risk management framework

— *Organisational culture*: includes communication, the 'tone at the top' clear ownership of each objective, training, performance measurement and knowledge-sharing.

8.10 At this point the impact of performance incentive schemes and any explicit or implicit organisational values should also be considered.

8.11 Robert Simons looked at cultural factors in an article in the *Harvard Business Review* (Simons, 1999). He highlights how an aggressive can-do culture often arises when a company's sales and profits soar, and leads to bold initiatives and satisfied clients, but also can end up silencing any messenger carrying bad news. Simons has developed a tool that he calls the risk exposure calculator, which shows the pressure points present in every organisation that lead to increased risk and are a function of the company's circumstances and management style. There are three dimensions to this tool:

— *Growth*. This looks at the pressures for performance within the organisation, the rate of expansion of the business and the level of inexperience in key employees.

— *Culture*. This covers the rewards the organisations gives for entrepreneurial risk-taking, the level of executive resistance to bad news and the amount of internal competition.

— *Information management*. This focuses on the complexity and velocity of transactions in the business, the amount of gaps in diagnostic performance measures and the degree to which decision-making is decentralised.

8.12 Though the scores from the tool are purely subjective, they are intended to raise awareness of the issues and indicate whether the organisation is fundamentally safe. It needs to be careful, or it is at risk and needs to take action to address the level of risk. Simons concludes his article by suggesting five questions which each organisation needs to ask itself:

— *Belief systems.* Have senior managers communicated the core values of the business in a way that people understand and embrace?

— *Boundary systems.* Have managers in the organisation clearly identified the specific actions and behaviours that are off-limits?

— *Diagnostic control systems.* Are the diagnostic control systems adequate at monitoring critical performance variables?

— *Interactive control systems.* Are the control systems interactive and designed to stimulate learning?

— *Internal controls.* Is sufficient attention paid to traditional internal controls?

8.13 Simon's philosophy is clearly similar to that of the FSA, which, in its draft guidance, says:

"A firm should ensure that all employees are aware of their responsibility and role in operational risk management, and are suitable and capable of performing these responsibilities, through the establishment and maintenance of:

(1) appropriate segregation of duties and supervision of employees in the performance of their responsibilities;
(2) appropriate recruitment and, as necessary, subsequent review processes to consider the fitness and propriety of employees, including their honesty, integrity and reputation, competence and capability and financial soundness;
(3) appropriate systems and procedures manuals that employees may refer to as required;
(4) training processes that enable employees to attain and maintain appropriate competence;
(5) appropriate disciplinary and termination of employment policies and procedures that are enforced.

When controlling the impact that employees may have on its susceptibility to operational losses, a firm should pay particular attention to approved persons and other positions of high personal trust (for example, security administration, payment and settlement functions). There are specific rules and guidelines for approved persons and for the apportionment of senior management responsibilities."

8.14 It is clear that the people side of the organisation is of fundamental importance in looking at operational risk: "Does the organisation have the ability to admit mistakes? Does it suffer from 'key person syndrome'? To what extent is, and should, maverick behaviour be tolerated or encouraged?" The recruitment and selection process will influence how those in the organisation behave, as will the approach to training and development.

8.15 Modern organisational development theory has a lot to say about the composition of teams, especially top teams, and their impact on organisational effectiveness. Perhaps the best known indicator in this field is the Myers-Briggs type indicator (MBTI) (Quenk, 1999). This is an instrument that has been exhaustively researched over 50 years, and seeks to make Carl Jung's theory of psychological types understandable and useful in a business environment. It examines differences in preferences in individuals that result from:

— whether they prefer to focus externally or internally (extraversion/introversion);
— the way in which they prefer to take in information;
— how they prefer to make decisions; and
— how they orient themselves to the external world.

8.16 From this, it categorises respondents into one of 16 types. Jung's theory suggests that differences in behaviour result from people's inborn tendencies to use their minds in different ways. As people act on these tendencies, they develop patterns of behaviour. The 16 types reflect the different patterns of behaviour that are observed.

8.17 A team that works well together is not a chance event. When teams understand their own styles and those of others, they are more likely to be effective. Research has shown that the more similar the psychological types in a team, the sooner the team members will understand each other. However, while groups with high similarity may reach decisions more quickly, they are more likely to make errors, owing to inadequate representation of all viewpoints. Groups with many different types will reach decisions more slowly and painfully, but may reach better decisions because more viewpoints are considered.

8.18 Another well-known approach to enhancing team performance is Belbin's team role theory (Belbin, 1995). This has been developed through rigorous analysis of a wide range of teams over an extended period, which has led to the identification of different clusters of behaviour that underlie the success of teams. This has been formulated in nine team roles:

— *action oriented roles*: shaper, implementer and completer finisher;
— *people oriented roles*: co-ordinator, team worker and resource investigator;
— and
— *cerebral roles*: plant, monitor evaluator and specialist.

8.19 Belbin's research showed that there are a finite number of behaviours or team roles, which comprise certain patterns of behaviour, which can be adopted naturally by the various personality types found among people at work. It is argued that the accurate delineation of these team roles is critical to understanding the dynamics of any management or work team.

8.20 Clearly, these two approaches share some similarities. Indeed, research has been done to demonstrate the correlations between the MBTI types and the Belbin team roles (Higgs, 1996). The key point from an operational risk perspective is that the balance of a team, however measured, can significantly influence its risk profile.

8.21 People risks interact with other risks. The most obvious example of this is that people are always involved with computer systems, both in their design and development, and in their operation. As the FSA says, in Consultation Paper 142 (FSA, 2002):

> "The automation of processes and systems may reduce a firm's susceptibility to some 'people risks' (for example, by reducing human errors or controlling access rights to enable the segregation of duties and information security) but will increase a firm's dependency on the reliability of its IT systems."

8.22 This is a key point, which raises other issues such as:

— system design, the active involvement of users to make it work more effectively for them, and so avoid errors or misunderstandings;
— use of drop down lists/avoidance of manual typing; it is human nature to be lazy — do the first items on the drop down lists or the default values appear more often than seems reasonable, are there useful data fields that are optional;

— building in data entry checks to minimise poor data entry;
— ensuring that data entry staff understand the importance of entering the correct items and the possible results of poor data entry; and
— if staff raise issues with the system or if particular errors are cropping up regularly, is anything actually done about it? If not, staff will stop bothering to report problems or to monitor errors — as well as getting the impression that what they think does not matter.

8.23 Systems are implicated in many of the operational losses suffered by the company in our case study. Perhaps the most obvious example is the losses suffered in the direct writing arm.

8.24 The level of change will have a major impact on the level of people risk. Major re-engineering and downsizing projects can lead to a significant loss of experience by the organisation. A recent A M Best survey showed that one of the major causes of insurance company failure was excessive growth. Major expansion often leads to problems, particularly when it is unplanned.

8.25 The FSA highlights the fact that major change will result in an alteration of a firm's risk profile. Their draft guidance is as follows:

> "Before, during and after a significant change to its organisation, infrastructure or business operating environment, a firm should assess and monitor how this change will affect its risk profile. In particular, there may be an increase in operational risk from:
> (1) untrained or de-motivated employees or an expected significant loss of employees during a period of change or subsequently;
> (2) inadequate human resources or inexperienced employees carrying out routine business activities owing to the prioritisation of resources to the programme or project;
> (3) process or system instability and poor management information due to failures in integration or increased demand;
> (4) inadequate or inappropriate processes following business re-engineering."

8.26 Relationships are at the root of the soft issues. Personal relationships with those inside and outside the organisation can have a disproportionate influence on decisions made by senior executives. Given the central role of personal relationships, the development of appropriate measurements may have to come from a source such as occupational psychology models. The future of any business depends upon its customer relationships, so processes like complaint management and service level monitoring are critical. Those businesses that have the Government as a customer are exposed to significant political risk, as the recent experience of BAe Systems has demonstrated.

8.27 The case study company is clearly one with a high level of cultural risk. The pressure for growth from the U.S. parent has led to a series of risk decisions that have led to operational losses, for example the expansion into unfamiliar lines of business. The culture clash was responsible for the losses suffered, e.g. the failure of the stop loss reinsurance and the default on the loan. Deficiencies in management information have been implicated in the excessive losses in the direct writing arm, the change in the composition of the business mix and the IT overspends. In Simon's terms, there does not appear to be a common belief system, there is a lack of clarity in boundaries and the different types of controls are significantly deficient.

8.28 The case study is silent on the company's approach to segregation of duties and supervision of employees' recruitment and review processes, the availability of systems and procedure manuals, training and development processes and the company's approach to disciplinary action and termination of employment. However, from the other evidence available about the culture of the company, it seems likely that there were significant deficiencies. We have no direct evidence from our case study about the composition of the top team, but its performance would lead us to believe that it is dysfunctional. The use of the type of tools such as the MBTI and Belbin team role analysis, previously described, may have highlighted the imbalance in the team and suggested ways in which the level of risk could have been reduced.

8.29 The company in our case study has undergone a series of major changes, such as taking over a competitor and then being acquired itself by an overseas company, which has clearly increased the level of risk. The evidence suggests that the case study company paid inadequate attention to the quality of its relationships with its key stakeholders. These issues are highlighted by the circumstances leading to the loss of the block account in the case study.

8.30 In summary, the case illustrates a wide range of eventualities where failure to attend to soft issues has been the cause of real and significant operational losses. The traditional approach to the management of insurance businesses has emphasised the measurement of hard factors, but our case study suggests that something more is required. It is here that the risk indicator approach, described in Section 3, comes into its own.

8.31 The cause/effect risk map and the causal modelling work outlined above (see Section 6) illustrated that, although the manifestation of a loss may be simple enough to identify, the cause is likely to be considerably more complex, being a causal chain that involves both soft and 'non-soft' factors. Modelling it, even assuming that the data are available, is therefore a non-trivial task.

8.32 The consideration of soft issues leads to the question as to whether some form of qualitative risk rating would be desirable. For example, based on agreed criteria, such as the amount of change, the management experience, the personality profiles of the top team and a process quality rating, is it possible that a 'soft risk rating index' (similar to those used by ratings agencies) could be developed?

9. Reporting and Pulling the Threads Together

9.1 This section is intended to help readers formulate reports in a cohesive and useful manner. It considers what aspects should be included, where caveats may be appropriate to avoid misunderstandings, and provides one or two suggested communication tools.

9.2 The key aim is to communicate the burden of findings to, say, a risk committee, which is likely to be a group with diverse experiences and abilities, limited time and a mixture of personal interests. The first challenge is to tailor the communication to the audience — to communicate what is important, to get the right level of supporting technical information and to make it as clear as possible. The risk committee is unlikely to want to know about how the EVT threshold was determined or the number of iterations in the causal model, but it will want to know how serious is the risk that it might not be in business in the foreseeable future.

9.3 The group risk committee (on behalf of the board) and senior management want to know what operational risk means for their business. The report is likely to include:

- a preamble covering scope and purpose;
- an executive summary;
- some background about the company and its current situation;
- a summary of the key risks being faced and the organisation's risk appetite or ability to withstand risk, including any soft issues or qualitative aspects;
- an assessment of the key operational risks (size, volatility, how vital);
- an understanding and possibly quantification, possibly including implications for an internal capital assessment (ICA) and FSA discussions;
- the approach to managing, mitigating and generally coping with the risks — an assurance or otherwise that the business can cope;
- a comment on how the risks will be kept under review (monitored), how the risk process will be refreshed and reviewed;
- a description of the approach, work completed, methods and data — including any gaps and key assumptions;
- suggested way forward, for example future process improvements or data collection; and
- the overall results and conclusions.

9.4 The headings chosen naturally reflect the risk management cycle, although it is accepted that other structures may be equally valid. Each is discussed in more detail below.

9.5 A preamble covering scope and purpose may include the intended readership (the group risk committee), the purpose (to consider the capital requirements of MELG plc in respect of operational losses), the scope (definitions such as the risk of loss, resulting from inadequate or failed internal processes, people and systems or from external events, categories, cause/event/consequences and exclusions), and the context (e.g. first time such an exercise has been completed and the relation with other risk categories). Reliances and limitations (e.g. people's views taken at face value, limited data checking, constraints on data and quantification), other caveats (e.g. the assumed experience of the reader, the need to read the report as a whole) and the qualifications of the author would also be included.

9.6 Professional matters may need discussing. At this stage this would mean referring to Guidance Note 12, but arguably further more specific guidance may need to be considered by the profession; maybe some comment whether these risks have been considered in isolation and what attempts have been made to see how they integrate with other risks faced by the organisation in association with DFA modelling. (The question of professional liability is returned to in the conclusions.)

9.7 For the purpose of this paper we take the structure of the executive summary as read.

9.8 *Background.* This will include comment about the company and its current situation — what sort of changes it is undertaking, its business plans, any recent FSA visits or audit reports that are relevant, a general comment on organisation structure, systems of control and any recent or planned senior management change. It might also discuss the risk management cycle and how it is embedded in the organisation, or what the operational risk aspects are. It would be worth commenting on whether the review is being driven by fear of missing FSA approval, or due to perceived business (value) gains.

9.9 *Key risks.* This would summarise the key risk being faced by the organisation and discuss its risk appetite or ability to withstand risk. This is also a useful place to include comment on any soft issues or qualitative aspects. One communication tool is a chart like Figure 9.9.

9.10 Such a tool may be called a risk map, or a profile of risks. It displays the risks according to their frequency and severity of the loss when an event occurs:

— The bottom left quadrant represents low frequency, low severity losses that are not of significant cost to the organisation. These elements make up a 'background noise' level of operating loss that should be expected; they are not the ones for which capital needs to be set aside.
— The top left quadrant represents operational losses that are still relatively small in amount (severity), but are more frequent. These losses will represent a greater level of loss to the organisation. This is an area where use of risk mitigation controls could reduce the frequency of losses. The cost of additional controls in this case could well be cost effective. Fluctuations in frequency could lead to variation in the level of loss and, as such, capital should be set aside.

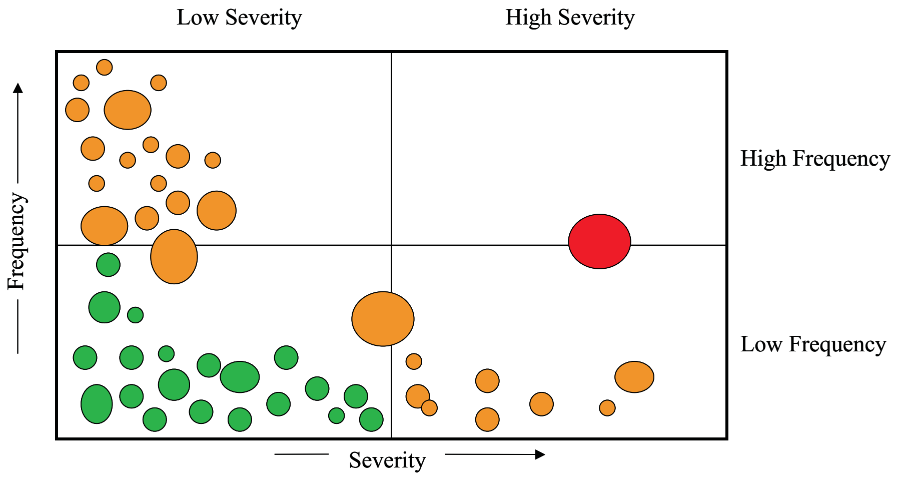

Figure 9.9. Frequency vs severity of operational losses

— The bottom right quadrant also represents risks of which the company should take note. These risks result in large losses on an infrequent basis. These losses can be difficult to control against, because they happen infrequently, but the amounts involved mean that it is worth considering risk mitigation measures. They are also likely to introduce the most volatility to losses experienced and, as such, it will be important to consider the capital that should be set aside to protect against any level of unexpected loss.
— The top right quadrant needs to be empty for a healthy business. In the case study there is one such risk edging into this area. The size of these losses and the frequency with which they occur mean that they are the single biggest cause of operational loss within the organisation, costing on average £50 million per year. We would recommend that controls are put in place to mitigate the loss from this risk area as a matter of priority.

9.11 Another technique is to display risks by risk type in descending order to focus attention on those risks where mitigation measures may have the most significant benefit.

9.12 A third communication method is shown in Figure 9.12, illustrating loss variability by customer process and strategic business line. Each bar represents the spread of operational losses that may arise from a particular process and class. The bar is not intended to cover every possible loss

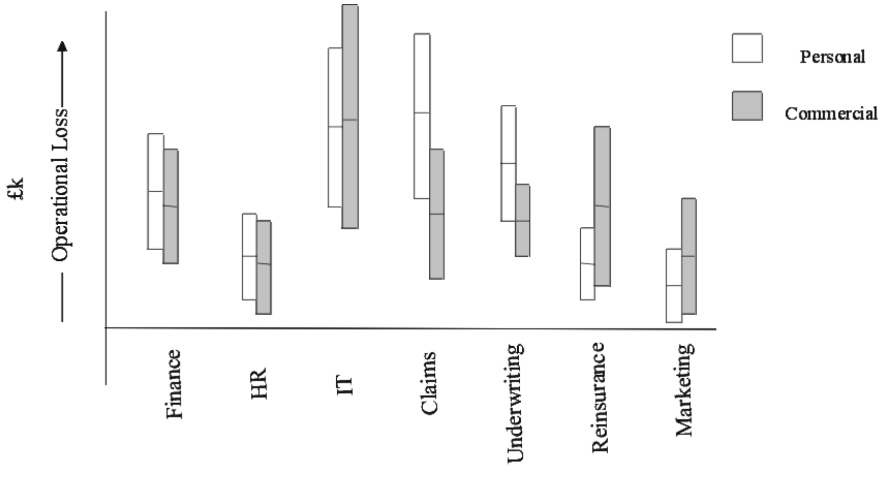

Figure 9.12. Operational loss by customer process and strategic business line

exhaustively, but represents the majority of possible outcomes (approximately 90% of losses).

9.13 The marker roughly in the middle of each bar represents the mean level of loss. This is not an indication of the capital required to withstand an unexpected level of loss. The unexpected level of loss is represented better by a point towards the top of each bar. The ideal is for a short bar (little variability) that lies close to the axis (limited average loss).

9.14 It can be seen that this section starts to include an assessment of key risks. A separate comment may help give the right focus, and may include further discussion about where the key risks lie — which functions are key, which processes, how they are monitored, their size, the likely volatility and in general how vital to the functioning of the organisation. To the extent not already covered, it would be the place to describe soft issues, the current change climate — any key recent or impending decisions and the general approach to strategic, reputational and legal risk.

9.15 The next section would set out an understanding or possibly quantification of risk, probably including implications for ICA and FSA discussions. In this way, the report would try to convey a sense of the character of each risk and how it was best dealt with. This is the section that needs to convey the importance of tackling any given risk in a new way, and whether there are possible combinations of events that could cause unexpected consequences. The understanding part of the report is critical, as quantification may be misleading or undesirable for certain categories of loss.

9.16 The next section would set out the approach to managing, mitigating and generally coping with the risks. In this section an indication would be given about how each risk is being (or will be) handled, and where overlaps/sharing of approach would be appropriate. There would be comment on the use of systems and controls, the use of capital, the impact of insurance lay-offs or reinsurance and other mitigation approaches. In some cases, it would be appropriate to accept the risk. It would also be the place, subject to professional caveats, to set out an assurance or otherwise that the business can cope. It is, of course, possible to envisage that the sections could be set out by considering each of the last four headings a risk at a time.

9.17 There should then be some comment on how the review and refreshment of the risk analysis should be achieved. This is to assure the readers, as the organisation keeps developing and changing, and as external circumstances move on, so all categories of operational risk will be kept under review, that they will be monitored, and in some ways, more importantly, that the risk management process itself will be refreshed, reviewed and subject to continual improvement.

9.18 The next section should include a description of the approach, work completed, methods and data — including any gaps and key assumptions. Each method used and relevant results might be discussed.

9.19 The suggested way forward would, for example, discuss future process improvements or data collection.

9.20 The final section would be a conclusion and setting out of overall results. This might be the place where correlations and independence are discussed, and where comment is made as to how the capital required by considering operational risk explicitly differs from the capital requirement of the enterprise using a DFA model based on implicit assumptions.

9.21 It would be important to comment on areas where the operational risk is such that risk mitigation measures could be considered as a means of reducing the overall capital requirement; further, where an allocation of operational risk across different business units might lead to a different allocation of risk based capital, and the implications for unit (and personal) profit goals.

9.22 If possible, there should be a simple summary of required operational risk capital and its split by line (e.g. in the case study between commercial, personal intermediary and personal direct).

9.23 Finally, there might be some comment on the key learning points identified during the exercise, e.g. the areas where risk management tools are inadequate and the cost benefit for improving them is positive, where systems or processes are clearly more or less reliable and where fraud losses are clearly too high.

10. Conclusions

10.1 We hope that this paper has served its purpose, which is to set out an overview of the landscape relating to operational risk, indications of possible approaches/current seeds of best practice, and to excite further attention to what could be a new area for developing actuarial involvement. We hope that it is timely in setting a framework for the profession.

10.2 It is still early days, and we must be wary of running too fast — before we can walk. It has to be a matter of 'first things first'. Whilst not strictly actuarial in some past senses of the word, this means beginning by identifying, assessing and understanding operational risk, and being able to view various forms of control as important, as well as understanding their impact — all before using statistical measurement techniques. This requires insight into, and understanding of, process management, organisational design including defining roles and responsibilities, occupational psychology and general management. The actuarial analytic training is good grounding for such work, but by no means a passport to success.

10.3 Starting at the beginning also implies asking questions about whether the board understands risk — the organisation's ability to bear risk or its risk appetite, as well as considering how the board itself can be a source of risk. Strategic error is often critical, particularly if combined with dominance risks, a culture which encourages risk taking and achievement, and incentive plans that encourage short-term delivery at the expense of medium-term value and capital management. Strategic error and risk are inevitably closely connected with operational risk.

10.4 We believe that ultimately understanding operational risk should be driven by the desire for business success and value creation — more so than the fear of failing FSA tests or even the risk of complete ruin — vital though these later two motivators should be.

10.5 Moving to a vision for the future management of operational risk will mean the need to start to collect data as soon as sensible. Appropriate liaison with other interested parties may help, and design of relevant reporting forms (or on-line mechanisms) might involve capturing 'near misses' and organisational culture issues, as well as ensuring sensible capture of useful statistical data.

10.6 The relative importance of operational risk compared with insurance or market risk is unclear. Our illustrations show a relatively small operational risk — only 2% of net premiums on average. Further work is needed to quantify the real impact: it could easily be three, four or more times the illustrated level, and comment would be welcome.

10.7 Nevertheless, we believe that, as thinking develops, operational risk will assume greater importance in terms of capital requirements and management thinking than at present. The rationale for this is that much of what is now considered insurance risk (be it based on premium or reserve), and even market risk, has its root cause in poor operational process. The concept of cause/event/consequence will inevitably drive attention to operational causes of loss.

10.8 Naturally, as this happens, there will be an increasing need for, and interest in, quantification. This will lead to discussion about methods and then about underlying assumptions and concepts to do with diversification of risk, correlation, new mitigation techniques and so on. These are fields ready and waiting for actuarial involvement.

10.9 We strongly believe that the actuarial profession should be considering how to better position itself. This could mean development of new courses, training and exams (or wider risk qualifications); it could mean development of new actuarial guidelines; it could mean involvement through the risk and regulatory co-ordinating group of an impact study across industry boundaries; it could mean sponsoring academic and practical research; it could mean starting something as basic as a life, general and pensions industry operational risk database. Whatever it means, we can only see good in it for adventurous and outward looking actuaries.

10.10 Independence and the ability to speak the unspeakable are valuable contributions that a well disciplined profession can make.

10.11 Equally, while an actuarial role exists and can be developed, we are not alone and need to work with other professions. Our ability to contribute may require development, but it also requires interaction or liaison and a new mind set.

10.12 As well as being an opportunity, there are huge concerns for the profession. As always, we need to be clear about claiming expertise that we do not possess. Our skills involve synthesising information from others, working with others to make sense of information, and possibly designing frameworks for quantification.

10.13 In terms of future work, again there is no shortage of things to be done. Here is a preliminary list; we would welcome comment from the profession to help strengthen and prioritise these topics:

— developing a deeper understanding of causal modelling techniques and their implication for risk modelling and analysis;
— a quantitative impact study, to help obtain industry based estimates on the quantum of operational risk;
— more detailed development of risk indicators and exposure to risk measures;
— development of a more consistent categorisation framework; while we understand the importance of defining risk tailored to a given organisation's needs, we think, ultimately, that this will slow down progress, as too much time will be taken in comparing categories which fundamentally have minimal difference;
— commencing a shared, confidential data collection service for the industry;

— developing new methods based on value at risk approaches, market measures (betas) and other techniques;
— deepening our understanding of systems, processes, controls and organisational design (roles and responsibilities); changing our own attitudes to 'soft issues' and building insights into the vital areas of culture and behaviours — we may not wish to become experts in all these fields, but our thinking should be good enough to ensure we can act sensibly as facilitators and integrators;
— considering new forms of risk management or mitigation, including use of insurance, cross sector aggregation, securitisation and other alternative forms of risk transfer — this might go as far as insurance product design to handle operational risk and subsequent rating; and
— ensuring that professional guidance and education are adapted to meet emerging needs.

10.14 "I do not want my house to be walled in on all sides and my windows to be stuffed. I want the skills and experiences of all peoples and professions to be blown through my house as freely as possible. But I refuse to be blown off my feet by any." With due respect and regard for Mahatma Gandhi, whose wonderful words we have taken the liberty of adapting, we need to learn from others, be open to new ways, but be strong enough to work out our own role. There is much to do and much to gain by open-minded exploration of this new area.

Acknowledgements

This has been a true team effort. Each member of the working party has made a significant contribution. Like all such efforts, with more time the output could be further improved, and we collectively shoulder the responsibility for errors and omissions.

We would particularly like to thank the scrutineers for their helpful contributions, attendees at GIRO for their observations, Andrew Hitchcox and the General Insurance Board for their support, Charles Ng for his assistance with modelling, Marie-José Gazères de Baradieu for her unflappable positive help with typing and meeting organisation, the Institute staff, all those who we spoke with in developing ideas, and any one else who has helped in whatever way.

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APPENDIX A

BBA GOLD DATABASE CATEGORIES

The British Bankers Association co-ordinate a database of operational risk losses on behalf of many U.K. banks. These losses are categorised at three levels, and the headings (publicly available from the BBA website) are set out below for interest, and although they relate to banks, we believe that they can act as a useful indicator of the type of operational risks that might be experienced. As mentioned in the paper, these headings are under current review.

Tier 1 — People

Tier 2	Tier 3
Employee fraud/malice (criminal)	— Collusion — Embezzlement — (Deliberate) sabotage of bank reputation — (Deliberate) money laundering — Theft — physical — Theft — intellectual property — Programming fraud — Other
Unauthorised activity/rogue trading/employee misdeed	— Misuse of privileged information — Churning — Market manipulation — Activity leading to deliberate mis-pricing — Activity with unauthorised counterparty — Activity in unauthorised product — Limit breach — Incorrect models (intentional) — Activity outside exchange rules — Illegal/aggressive selling tactics — Ignoring/short-circuiting procedures (deliberate) — Other
Employment law	— Wrongful termination — Discrimination/equal opportunity — Harassment

	— Non-adherence to other employment law
	— Non-adherence to health and safety regulations
	— Other
Workforce disruption	— Industrial action
	— Other
Loss or lack of key personnel	— Lack of suitable employees
	— Loss of key personnel
	— Other

Tier 1 — PROCESS

Tier 2	Tier 3
Payment/settlement	— Failure of/inadequate internal payment/settlement processes
Delivery risk	— Losses through reconciliation failure
	— Securities delivery errors
	— Limit breach
	— Insufficient capacity of people or systems to cope with volumes
	— Other
Documentation or contract risk	— Document not completed properly
	— Inadequate clauses/contract terms
	— Inappropriate contract terms
	— Inadequate sales records
	— Failure of due diligence
	— Other
Valuation/pricing	— Model risk
	— Input error
	— Other
Internal/external reporting	— Inadequate exception reporting
	— Accounting/book-keeping failure/inadequate data
	— Inadequate risk management reporting
	— Inadequate regulatory reporting
	— Inadequate financial reporting
	— Inadequate tax reporting
	— Inadequate stock exchange/securities reporting
	— Non-adherence to Data Protection Act/Privacy Act/similar

	— Other
Compliance	— Failure to adhere to internal compliance procedures
	— Failure of external compliance procedures
	— Breach of Chinese walls
Project risk/change management	— Inadequate project proposal/plan
	— New product process inadequacies
	— Project overruns
	— Other
Selling risks	— Inappropriate product selection
	— Product complexity
	— Poor advice (including securities)
	— Other

Tier 3 — Systems

Tier 2	Tier 3
Technology Investment risk	— Inappropriate architecture — Strategic risk (platform/suppliers)
	— Inappropriate definition of business requirements
	— Incompatibility with existing systems
	— Obsolescence of hardware
	— Obsolescence of software
	— Other
Systems development and implementation	— Inadequate project management — Cost/time overruns
	— Programming errors (internal/external)
	— Failure to integrate and/or migrate with/from existing systems
	— Failure of system to meet business requirements
	— Other
Systems capacity	— Lack of adequate capacity planning
	— Software inadequate
	— Other
Systems failures	— Network failure
	— Interdependency risk
	— Interface failures
	— Hardware failure
	— Software failure

	— Internal telecommunication failures
	— Other
Systems security breach	— External security breaches
	— Internal security breaches
	— Programming fraud
	— Computer viruses
	— Other

Tier 1 — External Events

Tier 2	Tier 3
Legal/public liability	— Breach of environmental management
	— Breach of fiduciary/agency duty
	— Interpretation of law
	— Misrepresentation
	— Other
Criminal activities	— External frauds/cheque fraud/forgery
	— Fraudulent account opening by client
	— Masquerade
	— Blackmail
	— Robberies (+ theft)
	— Money laundering
	— Terrorism/bomb
	— Disruption to business
	— Physical damage to property
	— Arson
	— Other
Outsourcing/supplier risk	— Bankruptcy of supplier
	— Breach of responsibility (misuse of confidential data)
	— Inadequate contract
	— Breach of service level agreement
	— Supplier/delivery failure
	— Inadequate management of suppliers/service providers
	— Other
Insourcing risk	— Insourcing failure
Disasters and infrastructural utilities failures	— Fire
	— Flood
	— Other natural (geological/meteorological)
	— Civil disasters

	— Transport failure
	— Energy failure
	— External telecommunications failure
	— Disruption to water supply
	— Unavailability of building
	— Other
Regulatory risk	— Regulator changes rules in industry/ country
Political/government risk	— War
	— Expropriation of assets
	— Business blocked
	— Change of tax regime
	— Other changes in law
	— Other

APPENDIX B

MELG: ILLUSTRATIVE RISK MATRIX

The risk classification shown in this matrix is based on that in Annex 2 of the working paper on the treatment of operational risk (BCBS, 2001). We show the perceived risk to the bottom line of MELG for three business units.

Event type (category 1)	Event sub type (category 2)	MELG broker personal lines	MELG direct personal lines	MELG commercial lines
Internal fraud	Unauthorised activity	Low, due to generally low underwriting authorities and fixed rates	Low, due to generally low underwriting authorities and fixed rates	Moderate, due to higher authorities and bigger individual risks
	Theft and fraud	Low	Low	Moderate (more flexibility available on admin systems)
External fraud	Theft and fraud	Moderate (but should be low)	Moderate (but should be low)	Moderate to high
	Systems security	Moderate to high (weak legacy systems)	Moderate	Moderate to high (weak legacy systems)
Employment practices/ workplace safety	Employee relations	Moderate (broker vs direct culture issues)	Moderate (broker vs direct culture issues)	Low (culturally largely intact post merger/ acquisition)
	Safe environment	Low	Low	Low
	Diversity and discrimination	Low	Low	Low
Clients, products and business practices	Suitability, disclosure and fiduciary	Moderate	Moderate	Low
	Improper business/market practice	Low (no recent sign of cartels, dodgy deals, etc.)	Low (no recent sign of cartels, dodgy deals, etc.)	Low (no recent sign of cartels, dodgy deals, etc.)
	Product flaws	Moderate (low individual, high volume)	Moderate (low individual, high volume)	High (high individual sizes, moderate volume, possible lack of experience in senior team?)
	Selection, sponsorship and exposure	Moderate to high — should be low (not much sponsorship or advertising to general public), but rumour over parental support	Moderate to high — should be low (not much sponsorship or advertising to general public), but rumour over parental support	Moderate to high — should be low (not much sponsorship or advertising to general public), but rumour over parental support

Event type (category 1)	Event sub type (category 2)	MELG broker personal lines	MELG direct personal lines	MELG commercial lines
	Advisory activities	None (broker's role)	Low to moderate (care over whether staff in practice offer advice or make suggestions to customers)	None (broker's role)
Damage to physical assets	Disasters and other events	Moderate (brokers can carry on with some activity in the meantime)	Moderate to high — need to maintain direct contact and response to customers	High — should be moderate as per personal broker but disaster recovery plan is several years out of date and misses out a key new system
	Systems	High (high volume)	High (even more dependent than personal broker)	Moderate (lower volumes and many products could be rated using paper tables if required)
Execution, delivery and process management	Transaction capture, execution and maintenance	High (garbage in, garbage out)	High (GIGO)	High(er) as data are more complex than for personal lines
	Monitoring and reporting	High (legacy systems make accurate reporting difficult, penalties including prevention form writing and adverse publicity for missing regulatory deadlines, etc. directors' and officers' claims potential if misreport to markets	High (as per personal broker, but no legacy system issues)	High (as per personal broker plus more complex reserving issues)
	Customer intake and documentation	High (high volume and standard docs so any problem would be multiplied)	High (as personal broker plus more automation of document production so more process risk)	Moderate to high (lower volumes)
	Customer/client account mgt	Do not handle customer accounts/ deposits (broker)	Do not handle customer accounts/ deposits	Do not handle customer accounts/ deposits (broker)
	Trade counterparties	Moderate (broker and reinsurer exposure)	Low (reinsurer exposure)	Moderate (broker and reinsurer exposure)

Event type (category 1)	Event sub type (category 2)	MELG broker personal lines	MELG direct personal lines	MELG commercial lines
	Vendors and suppliers	High — gaps in supplier monitoring capability in new system plus historic problems	High — gaps in supplier monitoring capability in new system plus historic problems	High — gaps in supplier monitoring capability in new system plus historic problems

APPENDIX C

DETAILS OF CURVE FITTING

C.1 *Frequency*

C.1.1 Poisson distribution $\lambda = 1.83$.

C.2 *Severity*

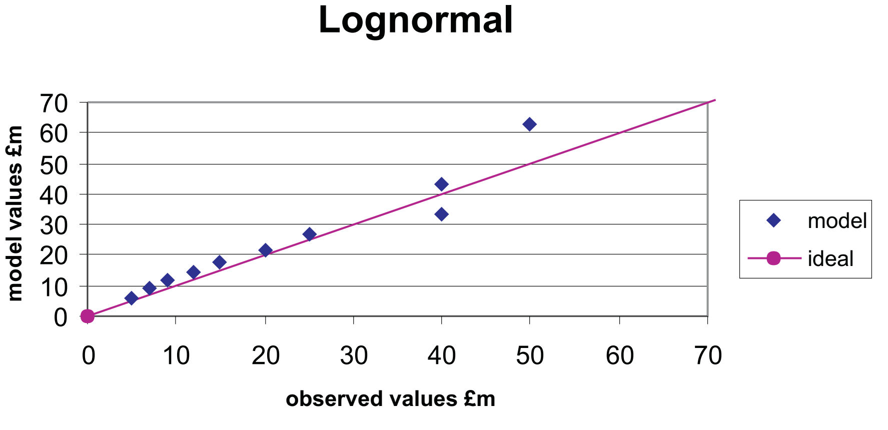
C.2.1 Lognormal distribution $\alpha = 2.979$, $\beta = 0.872$.

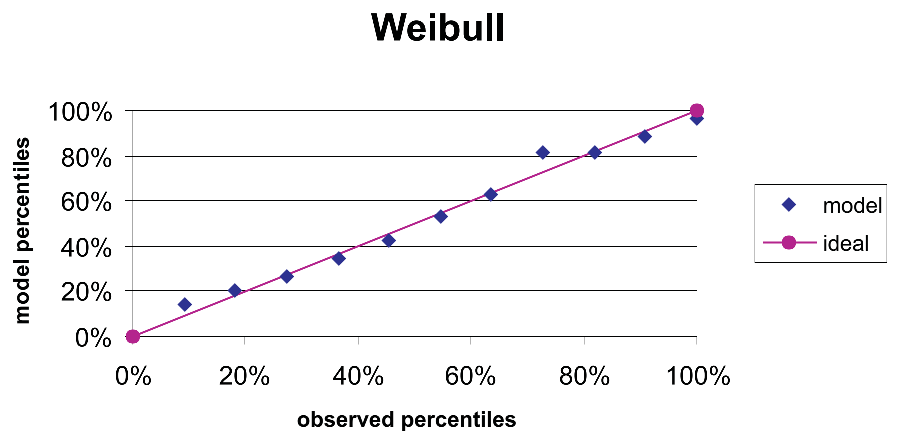
C.2.2 Weibull distribution $\alpha = 1.144$, $\beta = 25.444$.

C.2.3 Gamma distribution $\alpha = 1.468$, $\beta = 16.561$.

C.2.4 Extreme value distribution $u = 25$, $\lambda = 0.364$, $\xi = 0.000000295$, $\sigma = 105.002$.

C.3 *Q-Q Plots of Standard Curve Fitting Distributions*




Weibull
100%
80%
60%
40%
20%
0%
model percentiles
0%
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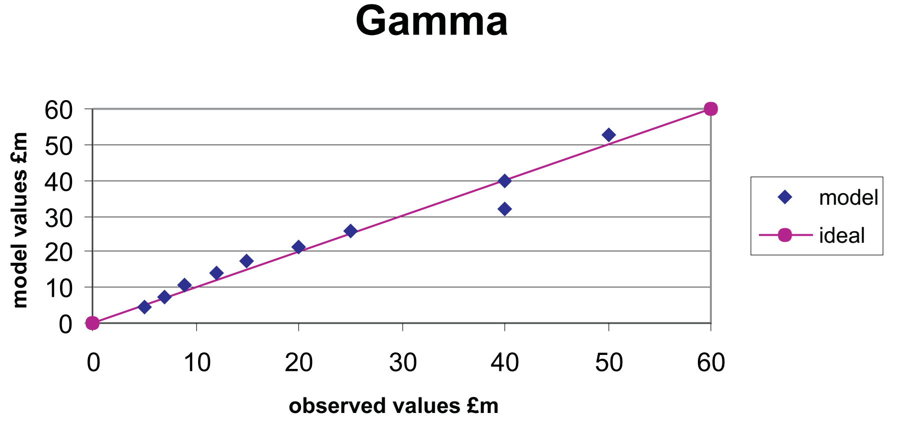
40%
60%
80%
100%
observed percentiles
model
ideal


Gamma
60
50
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30
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model values £m
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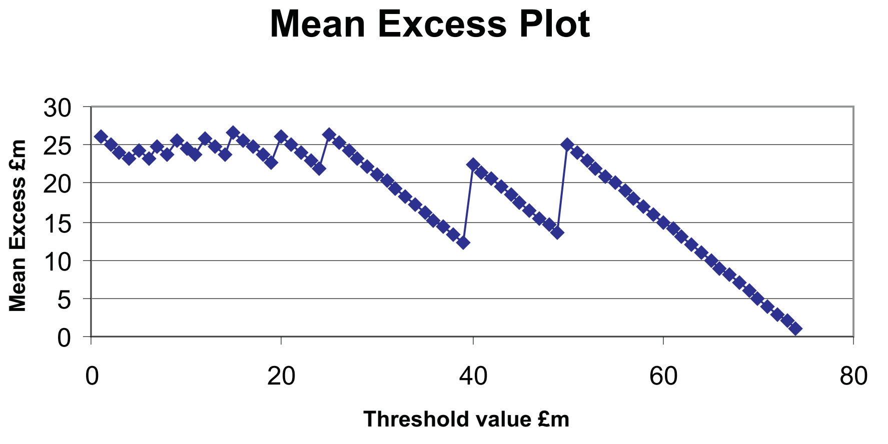
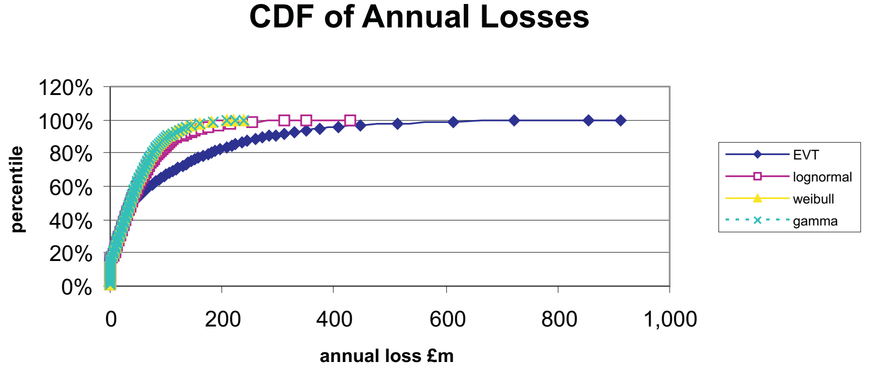
observed values £m
model
ideal

C.4 *Extreme Value Distribution Mean Excess Plot*



C.5 *Graph of Distribution of Outcomes for Modelled Annual Losses*



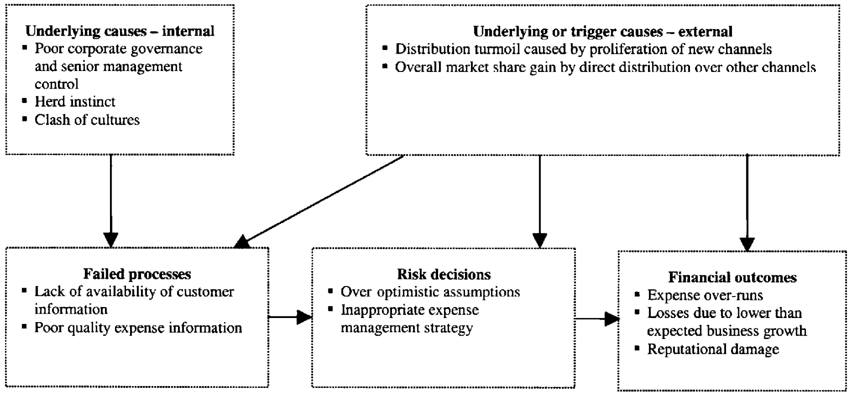
APPENDIX D

CAUSAL RISK MAPS AND BAYESIAN NETWORKS

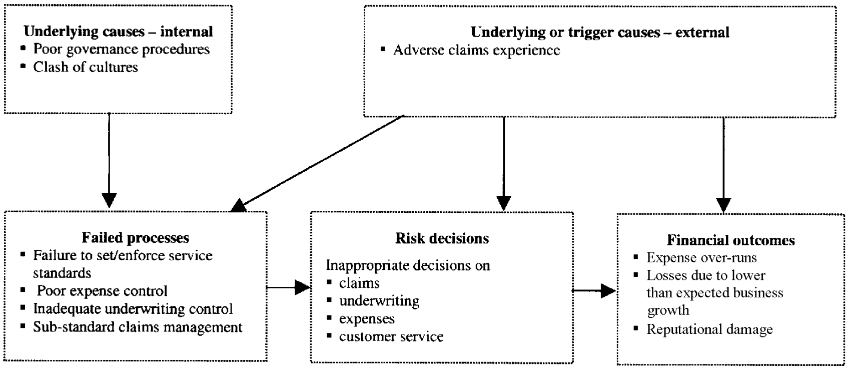
Sections D.1 to D.8 show additional examples of causal risk maps for some of the other operational risk events that have affected MELG.

The first diagram in Section D.9 shows pictorially a Bayesian network for MELG with central assumptions, using one of the proprietary software packages available. The subsequent diagrams show the effect of changing the assumptions for some of the nodes. In each case the nodes for which assumptions are being changed are shown as shaded.

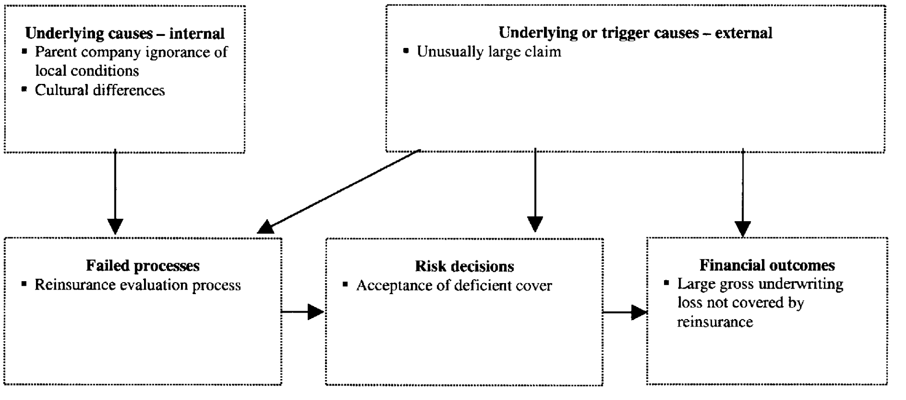
D.1 *Launch of Direct Writing*



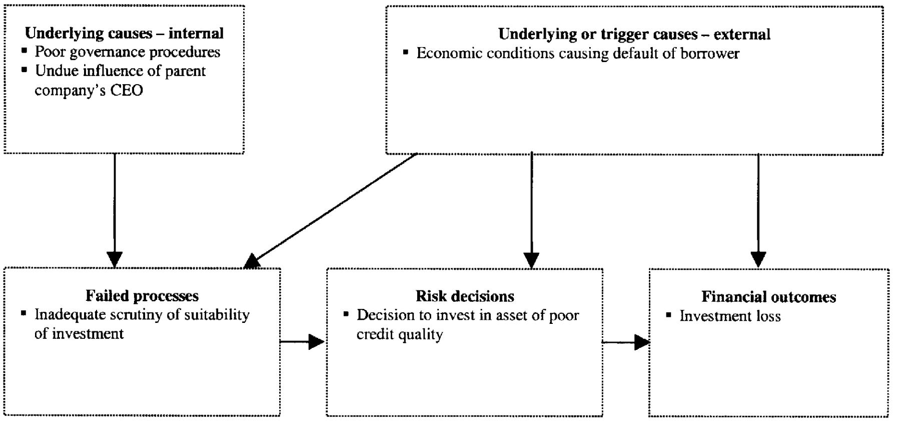
D.2 *Outsourcing of Claims Handling*



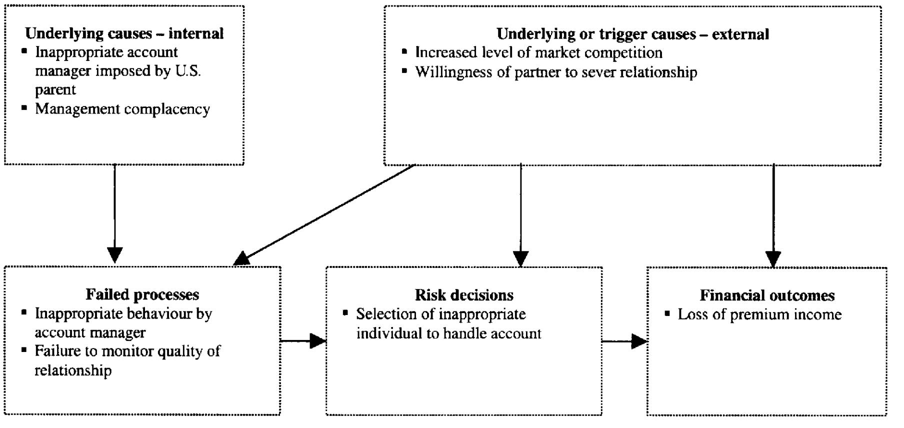
D.3 *Failure of Stop Loss Reinsurance*



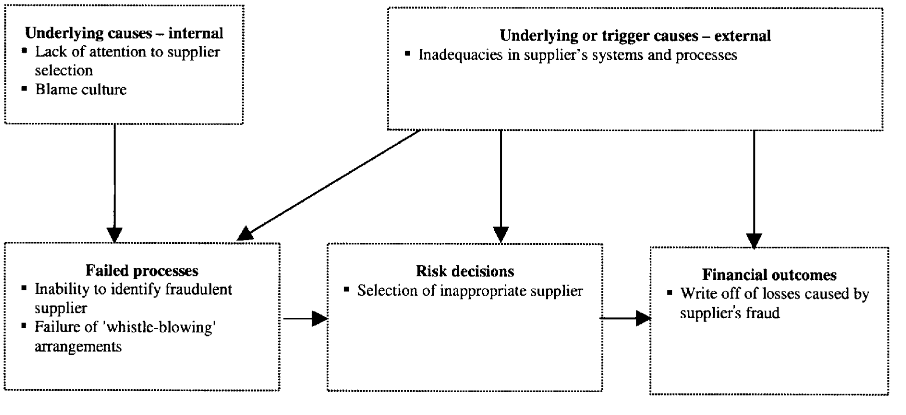
D.4 *Loan Default*



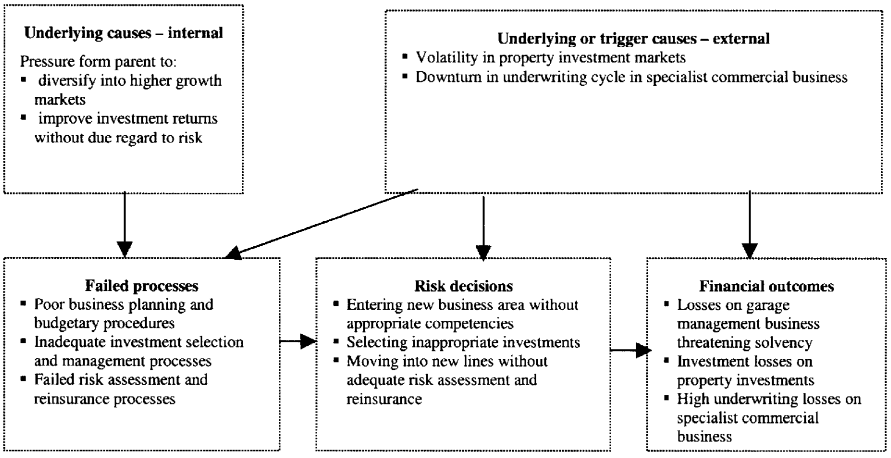
D.5 *Loss of Block Account*



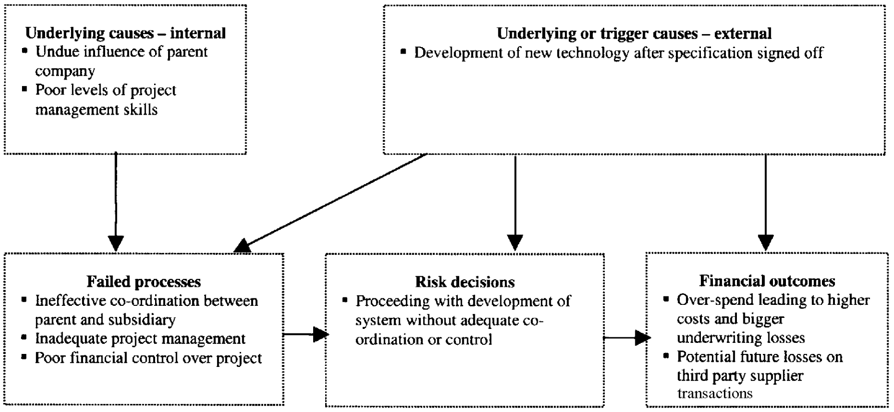
D.6 *External Supplier Fraud*



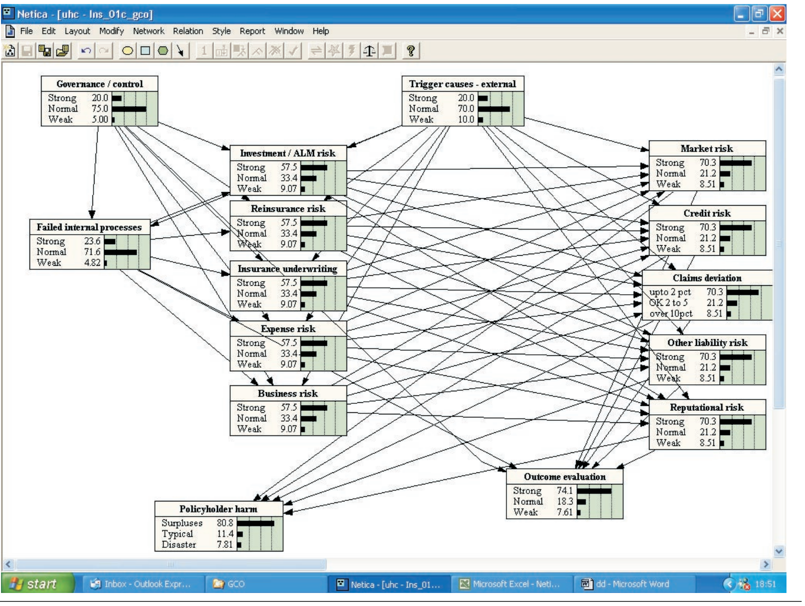
D.7 *Imposed Business Mix*

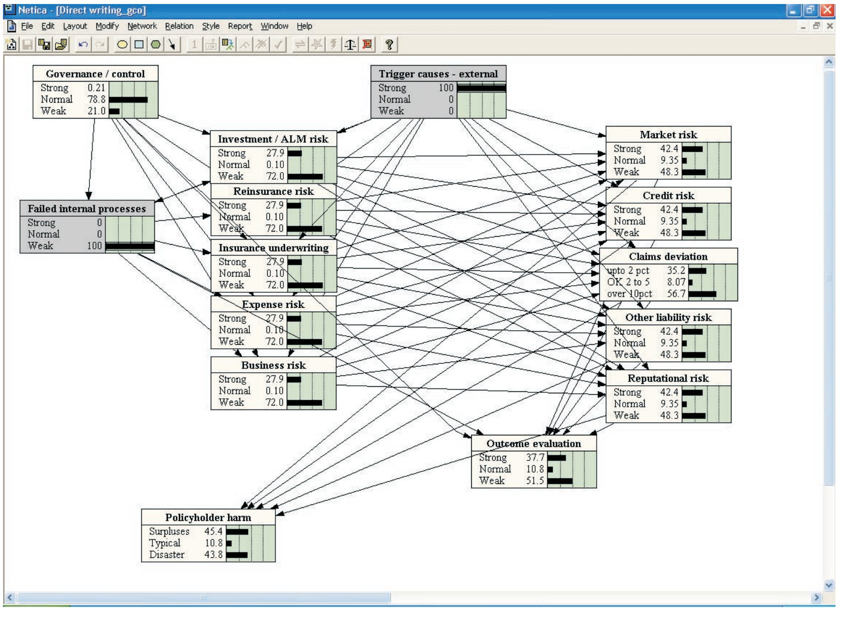


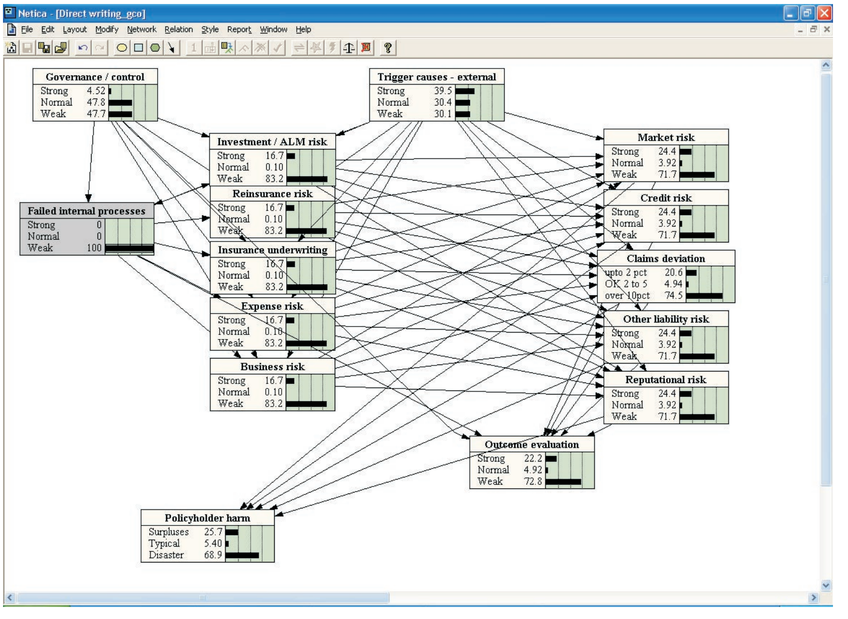
D.8 *IT Over Spends*

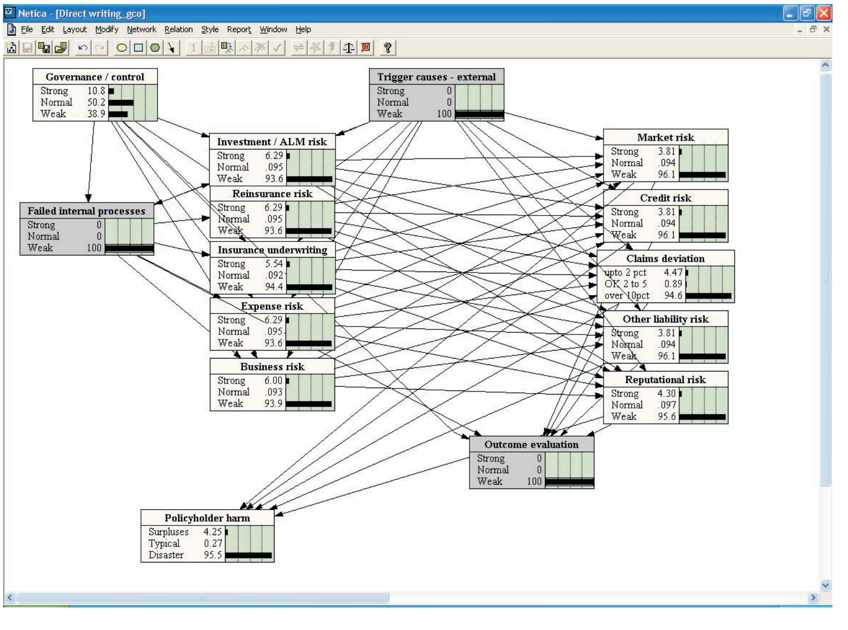


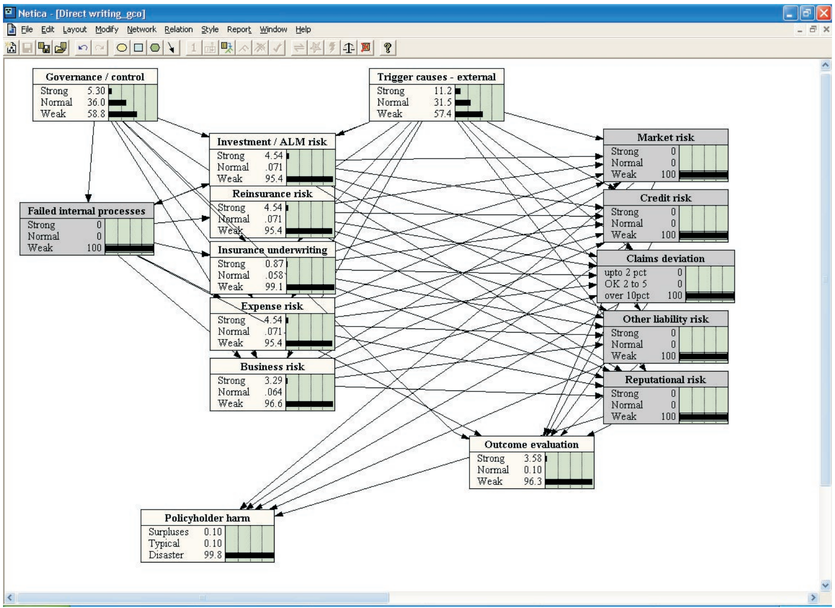
D.9 *Bayesian Causal Network Images*

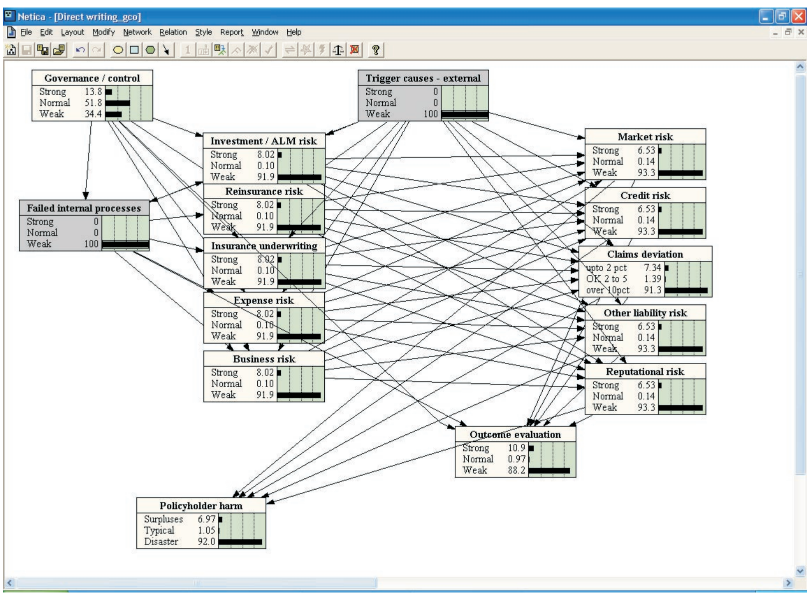


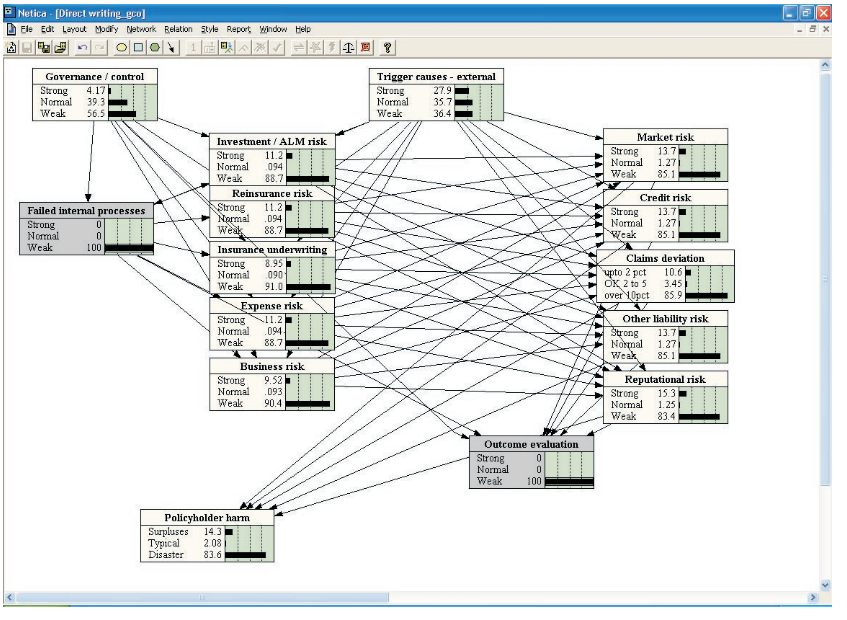



Netica - [Direct writing_gco]
File Edit Layout Modify Network Relation Style Report Window Help
Governance / control
Strong 4.52
Normal 47.8
Weak 47.7
Trigger causes - external
Strong 39.5
Normal 30.4
Weak 30.1
Investment / ALM risk
Strong 16.7
Normal 0.10
Weak 83.2
Market risk
Strong 24.4
Normal 3.92
Weak 71.7
Reinsurance risk
Strong 16.7
Normal 0.10
Weak 83.2
Failed internal processes
Strong 0
Normal 0
Weak 100
Credit risk
Strong 24.4
Normal 3.92
Weak 71.7
Insurance underwriting
Strong 16.7
Normal 0.10
Weak 83.2
Claims deviation
upto 2 pct 20.6
OK 2 to 5 4.94
over 10pct 74.5
Expense risk
Strong 16.7
Normal 0.10
Weak 83.2
Other liability risk
Strong 24.4
Normal 3.92
Weak 71.7
Business risk
Strong 16.7
Normal 0.10
Weak 83.2
Reputational risk
Strong 24.4
Normal 3.92
Weak 71.7
Outcome evaluation
Strong 22.2
Normal 4.92
Weak 72.8
Policyholder harm
Surpluses 25.7
Typical 5.40
Disaster 68.9


Netica - [Direct writing_gco]
File Edit Layout Modify Network Relation Style Report Window Help
Governance / control
Strong 10.8
Normal 50.2
Weak 38.9
Trigger causes - external
Strong 0
Normal 0
Weak 100
Investment / ALM risk
Strong 6.29
Normal .095
Weak 93.6
Market risk
Strong 3.81
Normal .094
Weak 96.1
Reinsurance risk
Strong 6.29
Normal .095
Weak 93.6
Failed internal processes
Strong 0
Normal 0
Weak 100
Credit risk
Strong 3.81
Normal .094
Weak 96.1
Insurance underwriting
Strong 5.54
Normal .092
Weak 94.4
Claims deviation
upto 2 pct 4.47
OK 2 to 5 0.89
over 10pct 94.6
Expense risk
Strong 6.29
Normal .095
Weak 93.6
Other liability risk
Strong 3.81
Normal .094
Weak 96.1
Business risk
Strong 6.00
Normal .093
Weak 93.9
Reputational risk
Strong 4.30
Normal .097
Weak 95.6
Outcome evaluation
Strong 0
Normal 0
Weak 100
Policyholder harm
Surpluses 4.25
Typical 0.27
Disaster 95.5


Netica - [Direct writing_gco]
File Edit Layout Modify Network Relation Style Report Window Help
Governance / control
Strong 5.30
Normal 36.0
Weak 58.8
Trigger causes - external
Strong 11.2
Normal 31.5
Weak 57.4
Investment / ALM risk
Strong 4.54
Normal .071
Weak 95.4
Market risk
Strong 0
Normal 0
Weak 100
Reinsurance risk
Strong 4.54
Normal .071
Weak 95.4
Failed internal processes
Strong 0
Normal 0
Weak 100
Credit risk
Strong 0
Normal 0
Weak 100
Insurance underwriting
Strong 0.87
Normal .058
Weak 99.1
Claims deviation
upto 2 pct 0
OK 2 to 5 0
over 10pct 100
Expense risk
Strong 4.54
Normal .071
Weak 95.4
Other liability risk
Strong 0
Normal 0
Weak 100
Business risk
Strong 3.29
Normal .064
Weak 96.6
Reputational risk
Strong 0
Normal 0
Weak 100
Outcome evaluation
Strong 3.58
Normal 0.10
Weak 96.3
Policyholder harm
Surpluses 0.10
Typical 0.10
Disaster 99.8


Netica - [Direct writing_gco]
File Edit Layout Modify Network Relation Style Report Window Help
Governance / control
Strong 13.8
Normal 51.8
Weak 34.4
Trigger causes - external
Strong 0
Normal 0
Weak 100
Investment / ALM risk
Strong 8.02
Normal 0.10
Weak 91.9
Market risk
Strong 6.53
Normal 0.14
Weak 93.3
Reinsurance risk
Strong 8.02
Normal 0.10
Weak 91.9
Failed internal processes
Strong 0
Normal 0
Weak 100
Credit risk
Strong 6.53
Normal 0.14
Weak 93.3
Insurance underwriting
Strong 8.02
Normal 0.10
Weak 91.9
Claims deviation
upto 2 pct 7.34
OK 2 to 5 1.39
over 10pct 91.3
Expense risk
Strong 8.02
Normal 0.10
Weak 91.9
Other liability risk
Strong 6.53
Normal 0.14
Weak 93.3
Business risk
Strong 8.02
Normal 0.10
Weak 91.9
Reputational risk
Strong 6.53
Normal 0.14
Weak 93.3
Outcome evaluation
Strong 10.9
Normal 0.97
Weak 88.2
Policyholder harm
Surpluses 6.97
Typical 1.05
Disaster 92.0


Netica - [Direct writing_gco]
File Edit Layout Modify Network Relation Style Report Window Help
Governance / control
Strong 4.17
Normal 39.3
Weak 56.5
Trigger causes - external
Strong 27.9
Normal 35.7
Weak 36.4
Investment / ALM risk
Strong 11.2
Normal .094
Weak 88.7
Market risk
Strong 13.7
Normal 1.27
Weak 85.1
Reinsurance risk
Strong 11.2
Normal .094
Weak 88.7
Failed internal processes
Strong 0
Normal 0
Weak 100
Credit risk
Strong 13.7
Normal 1.27
Weak 85.1
Claims deviation
upto 2 pct 10.6
OK 2 to 5 3.45
over 10pct 85.9
Insurance underwriting
Strong 8.95
Normal .090
Weak 91.0
Expense risk
Strong 11.2
Normal .094
Weak 88.7
Other liability risk
Strong 13.7
Normal 1.27
Weak 85.1
Business risk
Strong 9.52
Normal .093
Weak 90.4
Reputational risk
Strong 15.3
Normal 1.25
Weak 83.4
Outcome evaluation
Strong 0
Normal 0
Weak 100
Policyholder harm
Surpluses 14.3
Typical 2.08
Disaster 83.6

APPENDIX E

DFA MODEL DETAILS

The following pages summarise the four versions of a DFA model, as described in Section 7 of the paper. The underlying assumptions are based on the historic results (as shown in the FSA returns) of the leading six insurers' household and employer's liability accounts. These have been overlaid with the operational losses shown in Section 2.

Each version is summarised in terms of the mean projection of key financial items, followed by a funnel plot showing the probability distribution of the solvency ratio about its mean. The model is developed using a proprietary DFA package developed in excel and visual basics, as used in producing a paper 'Calibration of the general insurance risk based capital model' for the FSA, dated 25 July 2003.

Table E.1. Middle England Life and General plc, implicit operational risk, mean projections

Period ending	31/12/02	31/12/03	31/12/04	31/12/05	31/12/06	31/12/07	31/12/08
Net written premiums	1,694.625	1,798.400	2,027.619	2,241.204	2,396.794	2,560.651	2,788.329
Net earned premiums	1,643.664	1,560.205	1,771.082	2,130.014	2,315.385	2,474.922	2,669.691
Underwriting surplus for the year	(149.532)	(124.558)	(133.318)	31.367	3.294	(94.212)	(217.356)
Profit after tax	(452.882)	101.997	117.239	304.487	282.507	192.944	92.433
Total shareholders' funds	857.118	959.115	1,076.355	1,380.841	1,663.348	1,856.293	1,948.725
Net loss ratio	75.8%	70.6%	66.5%	60.7%	62.1%	65.9%	69.9%
Expense ratio	32.4%	36.2%	36.8%	36.6%	36.7%	36.9%	37.1%
Combined ratio	108.2%	106.8%	103.3%	97.3%	98.9%	102.8%	107.0%
Return on capital employed	−15.8%	4.0%	4.5%	10.1%	8.7%	5.8%	3.1%
Solvency ratio	50.6%	53.3%	53.1%	61.6%	69.4%	72.5%	69.9%

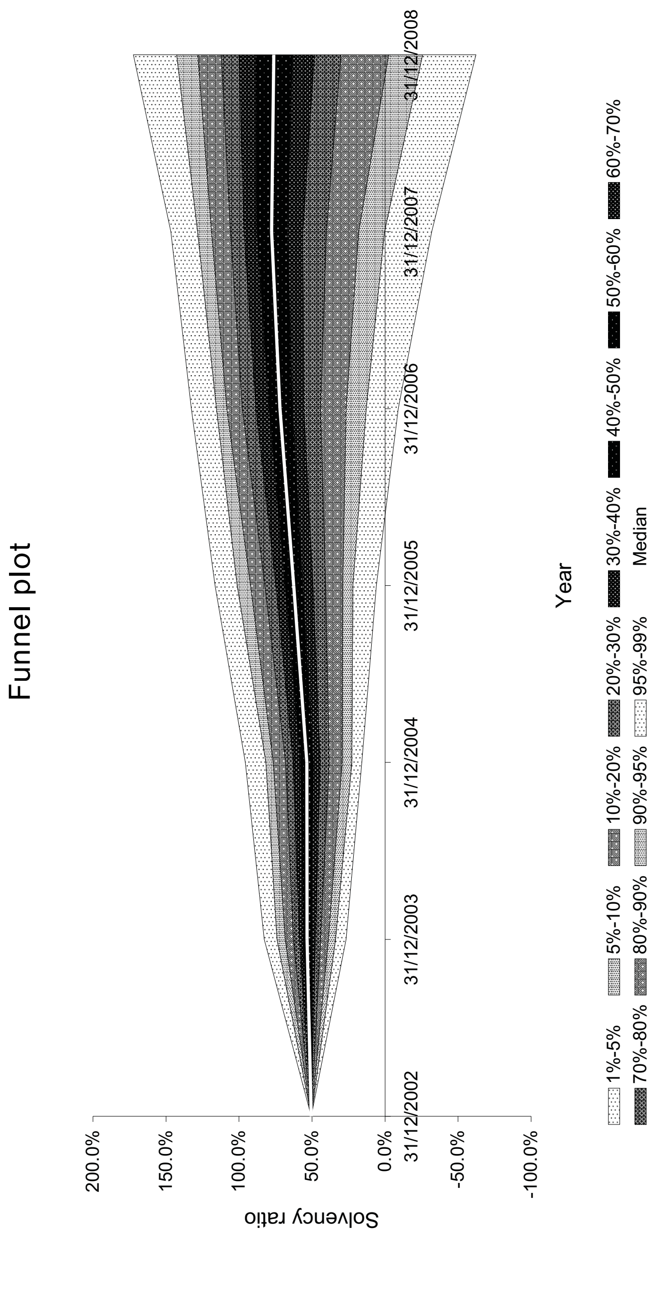

Funnel plot
Solvency ratio
200.0%
150.0%
100.0%
50.0%
0.0%
-50.0%
-100.0%
31/12/2002
31/12/2003
31/12/2004
31/12/2005
31/12/2006
31/12/2007
31/12/2008
Year
1%-5%
5%-10%
10%-20%
20%-30%
30%-40%
40%-50%
50%-60%
60%-70%
70%-80%
80%-90%
90%-95%
95%-99%
Median

Table E.2. Middle England Life and General plc, no operational risk

Period ending	31/12/02	31/12/03	31/12/04	31/12/05	31/12/06	31/12/07	31/12/08
Net written premiums	1,694.625	1,798.795	2,034.108	2,243.332	2,400.798	2,557.872	2,780.799
Net earned premiums	1,643.664	1,560.413	1,774.425	2,134.402	2,318.437	2,475.639	2,664.585
Underwriting surplus for the year	(149.532)	(69.857)	(84.944)	74.957	53.715	(32.834)	(141.291)
Profit after tax	(452.882)	153.551	165.730	350.762	331.767	252.857	172.902
Total shareholders' funds	857.118	1,010.669	1,176.399	1,527.162	1,858.928	2,111.785	2,284.687
Net loss ratio	75.8%	67.4%	64.0%	58.8%	60.1%	63.6%	67.3%
Expense ratio	32.4%	36.1%	36.6%	36.5%	36.6%	36.7%	36.9%
Combined ratio	108.2%	103.4%	100.6%	95.3%	96.7%	100.4%	104.2%
Return on capital employed	−15.8%	5.8%	6.0%	11.1%	9.7%	7.0%	4.8%
Solvency ratio	50.6%	56.2%	57.8%	68.1%	77.4%	82.6%	82.2%

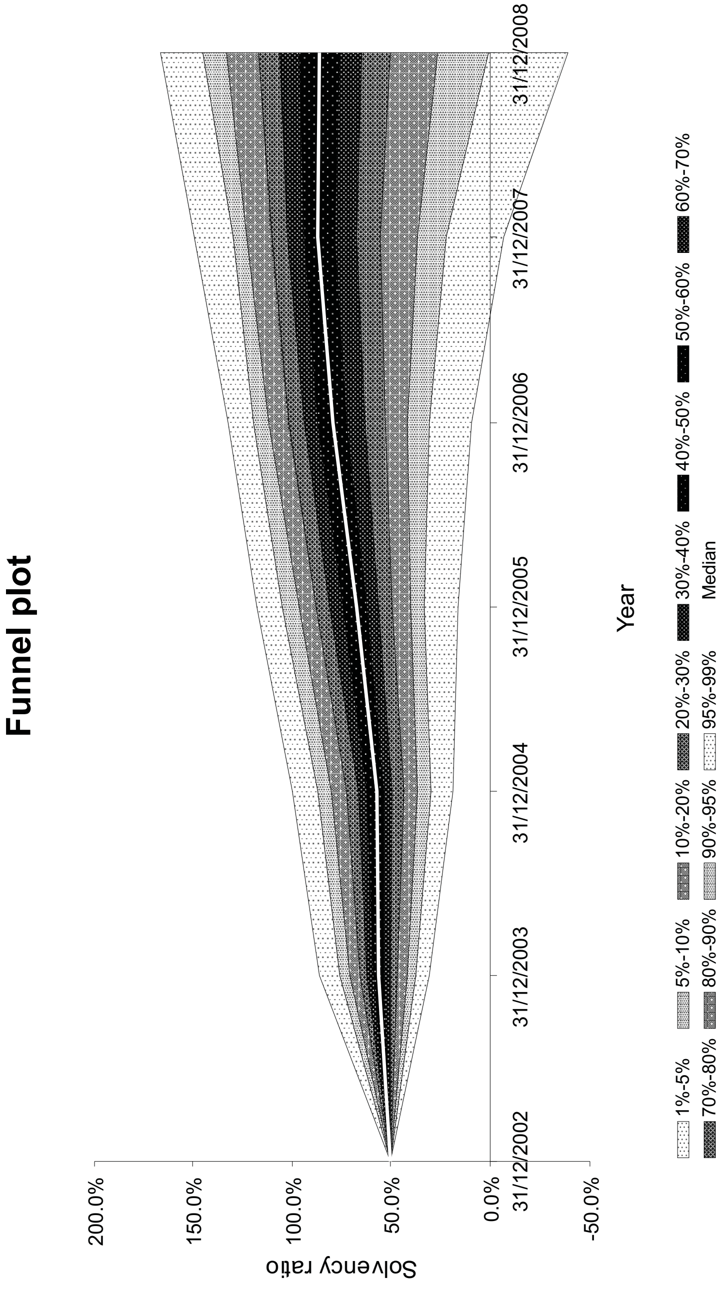

Funnel plot
Solvency ratio
200.0%
150.0%
100.0%
50.0%
0.0%
-50.0%
31/12/2002
31/12/2003
31/12/2004
31/12/2005
31/12/2006
31/12/2007
31/12/2008
Year
1%-5%
5%-10%
10%-20%
20%-30%
30%-40%
40%-50%
50%-60%
60%-70%
70%-80%
80%-90%
90%-95%
95%-99%
Median

Table E.3. Middle England Life and General plc, explicit operational risk

Period ending	31/12/02	31/12/03	31/12/04	31/12/05	31/12/06	31/12/07	31/12/08
Net written premiums	1,694.625	1,799.463	2,032.483	2,240.824	2,398.361	2,560.240	2,789.999
Net earned premiums	1,643.664	1,560.730	1,773.984	2,132.347	2,315.971	2,475.493	2,670.227
Underwriting surplus for the year	(149.532)	(86.505)	(105.593)	55.902	36.089	(55.597)	(145.643)
Profit after tax	(452.882)	138.094	146.072	333.504	318.205	235.410	169.952
Total shareholders' funds	857.118	995.212	1,141.284	1,474.789	1,792.993	2,028.403	2,198.355
Net loss ratio	75.8%	68.4%	65.1%	59.7%	60.9%	64.5%	67.4%
Expense ratio	32.4%	36.1%	36.6%	36.5%	36.6%	36.8%	36.9%
Combined ratio	108.2%	104.5%	101.8%	96.2%	97.5%	101.2%	104.3%
Underwriting profit	−8.8%	−4.8%	−5.2%	2.5%	1.5%	−2.2%	−5.2%
Return on capital employed	−15.8%	5.2%	5.3%	10.7%	9.4%	6.7%	4.8%
Solvency ratio	50.6%	55.3%	56.2%	65.8%	74.8%	79.2%	78.8%

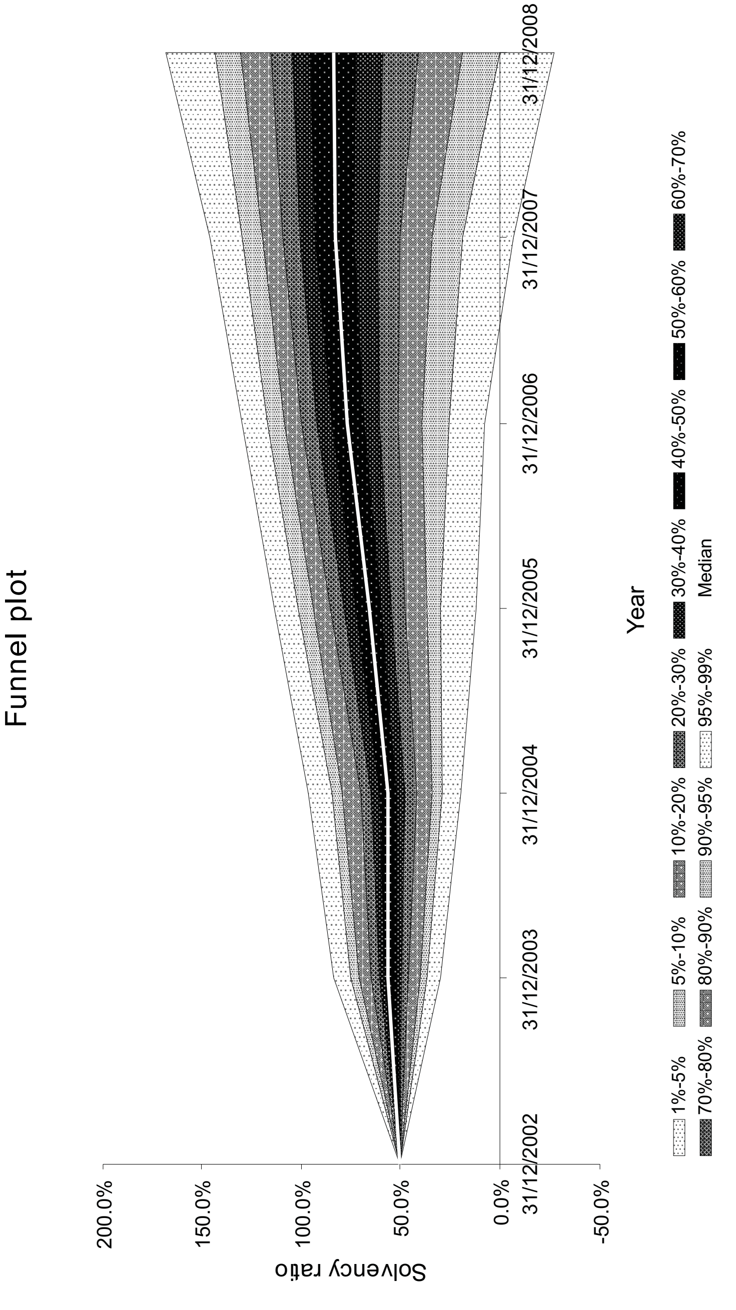
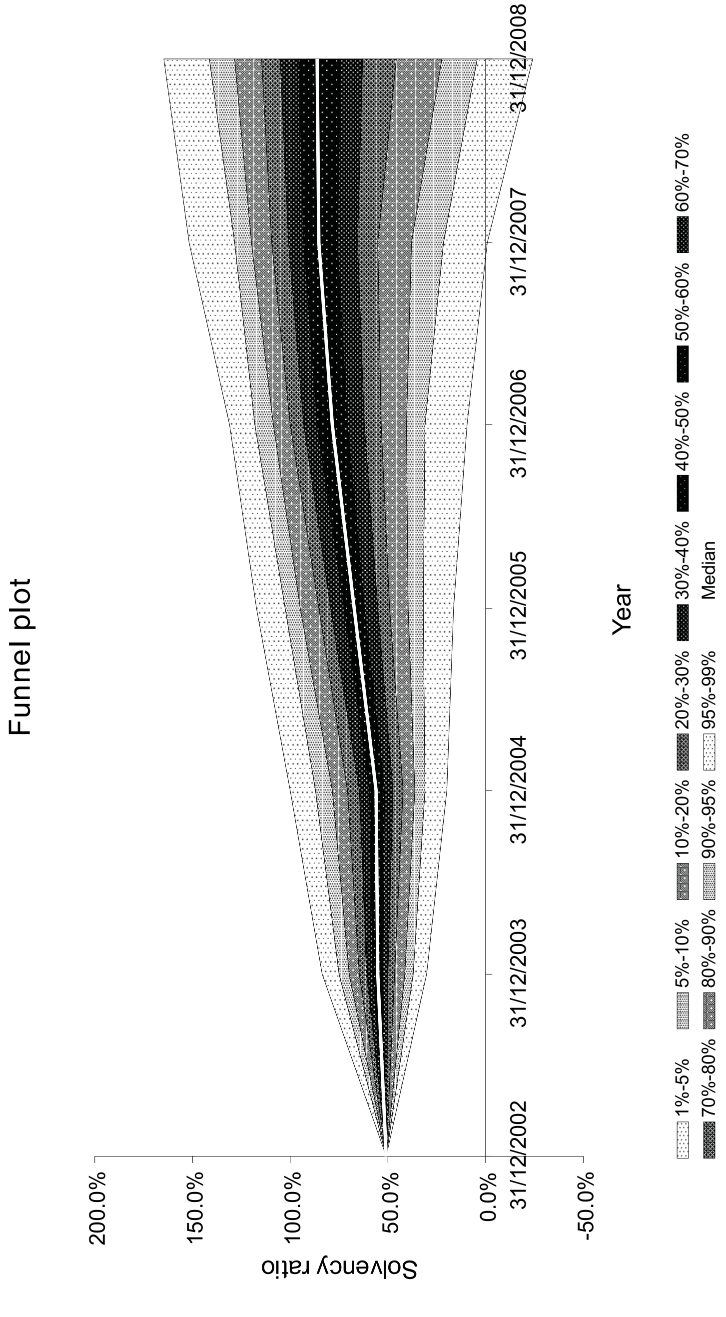

Funnel plot
Solvency ratio
200.0%
150.0%
100.0%
50.0%
0.0%
-50.0%
31/12/2002
31/12/2003
31/12/2004
31/12/2005
31/12/2006
31/12/2007
31/12/2008
Year
1%-5%
5%-10%
10%-20%
20%-30%
30%-40%
40%-50%
50%-60%
60%-70%
70%-80%
80%-90%
90%-95%
95%-99%
Median

Table E.4. Middle England Life and General plc, explicit operation risk (improved systems of control)

Period ending	31/12/02	31/12/03	31/12/04	31/12/05	31/12/06	31/12/07	31/12/08
Net written premiums	1,694.625	1,799.094	2,031.926	2,241.787	2,398.866	2,555.355	2,779.800
Net earned premiums	1,643.664	1,560.547	1,773.540	2,132.549	2,316.705	2,473.436	2,662.811
Underwriting surplus for the year	(149.532)	(84.272)	(98.459)	75.005	50.739	(46.619)	(159.419)
Profit after tax	(452.882)	140.381	152.968	351.172	332.356	245.322	162.181
Total shareholders' funds	857.118	997.499	1,150.466	1,501.638	1,833.994	2,079.315	2,241.497
Net loss ratio	75.8%	68.2%	64.7%	58.9%	60.3%	64.1%	67.9%
Expense ratio	32.4%	36.1%	36.6%	36.5%	36.6%	36.8%	36.9%
Combined ratio	108.2%	104.4%	101.4%	95.3%	96.8%	100.9%	104.9%
Return on capital employed	−15.8%	5.3%	5.6%	11.2%	9.7%	6.8%	4.5%
Solvency ratio	50.6%	55.4%	56.6%	67.0%	76.5%	81.4%	80.6%


Funnel plot
Solvency ratio
200.0%
150.0%
100.0%
50.0%
0.0%
-50.0%
31/12/2002
31/12/2003
31/12/2004
31/12/2005
31/12/2006
31/12/2007
31/12/2008
Year
1%-5%
5%-10%
10%-20%
20%-30%
30%-40%
40%-50%
50%-60%
60%-70%
70%-80%
80%-90%
90%-95%
95%-99%
Median