Integrating Pricing & Capital Modelling

GIRO Working Party

Adrian Ericsson
Andy Macnair
Buu Truong
Cathryn Dunlop
Darren Farr
David Marshall
Hannes van Rensburg
James Anderson
JB Crozet (Chairman)
Jennifer Gray
Lakshmi VS
Matthew Byrne
Michael Fung
Reeken Patel

Table of Contents

1 Introduction 7
1.1 Objective of the paper 7
1.2 Recommendations from GRIP 7
1.3 Evolution in Capital Modelling 8
1.3.1 Regulatory framework 8
1.3.2 Economic capital framework 8
1.4 Structure of the paper 9
2 Our Vision for an Integrated Framework 11
2.1 Introduction 11
2.2 Consistency in Approach & Assumptions 12
2.2.1 Common purpose 12
2.2.2 Consistency in assumptions 12
2.2.3 List of assumptions requiring consistency 13
2.3 Pricing Designed to Feed into Capital Modelling 14
2.3.1 Parameterisation of UW Risk 14
2.3.2 Centralised models for systematic risks 15
2.4 Capital Models Guiding Pricing Decisions 16
2.4.1 Capital allocation 16
2.4.2 Target returns on allocated capital 18
2.4.3 Examples of interaction between/within lines of business 19
2.5 Effective Communication Flow 20
2.5.1 The communication challenge 20
2.5.2 Example of communication flow 22
2.5.3 Data and information flow we would expect to see, and how used 22

2.6 Embedding… The Use Test 24
2.6.1 Criteria for an embedded process 24
2.6.2 Examples of practical ways of achieving embedding 25
3 Benefits, Practical Applications & Challenges 26
3.1 Introduction 26
3.2 Benefits of an Integrated Framework 26
3.2.1 Better understanding of the business 26
3.2.2 Robustness of capital modelling 26
3.2.3 Strengthening of the regulatory framework 27
3.3 Practical applications 28
3.3.1 Account pricing 28
3.3.2 Aggregation management 28
3.3.3 Business planning 29
3.3.4 Reinsurance purchasing 29
3.3.5 Performance monitoring 30
3.3.6 Other applications 30
3.4 Challenges 31
3.4.1 Communication 31
3.4.2 Difference in approach 32
3.4.3 Level of granularity 32
3.4.4 Timing 33
3.4.5 Technological resources 33
4 Survey of Current Practices 34
4.1 Introduction 34
4.2 Results of our Market Survey 34

4.2.1 Description of the survey 34
4.2.2 Key findings 35
4.2.3 Detailed findings 35
4.3 Practices in Life Assurance 39
4.3.1 Regulatory environment 39
4.3.2 Pricing & Capital Modelling practices 40
4.3.3 Observations 40
4.4 Practices in the Banking industry 41
4.4.1 Regulatory environment 41
4.4.2 Pricing & Capital Modelling practices 42
4.4.3 Observations 43

Executive Summary

Objective of the paper

The objective set for our working party by GRIP was that of helping the Profession with one of its latest challenges: the Integration of Pricing and Capital Modelling.

In the last decade, actuaries have dramatically increased their influence in these two areas, but their work has sometimes evolved in different directions:

- Pricing is typically focused on the transactional level, and does not usually give much consideration to the aggregation of underwriting risks at the organisational level.
- Capital Modelling is typically focused on determining capital requirement for regulatory purposes, without aiming to impact daily underwriting decisions.

It remains that both model the same underwriting risks, and there is therefore mounting pressure to integrate these two processes so that they produce a single, consistent picture of the business, albeit with different levels of granularity.

The pressure comes from Management who would like to reap further benefits and synergies from their investments in actuarial models; and from the Regulator, in particular under Solvency II, who would like to see both processes embedded within the business.

Practical recommendations and observations

We have attempted to offer practical recommendations to actuarial practitioners facing the challenge of integrating Pricing and Capital Modelling within their organisation.

First, we have established "Our Vision for an Integrated Framework" in order to 1) help identify principles and standards for an Integrated Pricing and Capital Modelling Framework ("IPCMF"), and 2) determine what integration would look like in practice. We have concluded that an IPCMF would demonstrate five qualities:

- Consistency in methodology, assumptions and data; with both Pricing and Capital Modelling aligned behind an underwriting strategy based on the insurance principles of developing a portfolio of risks, and benefiting from mutualisation and diversification.
- Pricing outputs designed to feed into Capital Modelling; based on a parameterisation of UW risk relying on Pricing analyses and on centralised models for systematic risks.
- Capital Models guiding Pricing decisions; via an allocation of capital at the line of business or individual transaction level and setting a target return on allocated capital for each transaction, which optimises the insurer's expected profit in the current market conditions.
- Effective communication flows between Pricing and Capital Modelling; overcoming the challenge of translating knowledge and information from Pricing into a form usable in a statistical Capital Model and vice versa.

- Embedding within the organisation; in other words aligning it with business current processes and used for key strategic or management decisions in the running of a firm

Second, we have discussed in "Benefits, Practical Applications & Challenges" the incentives to promote integration within the organisation but also the practical pitfalls and difficulties in doing so. In practice, the decision to integrate Pricing and Capital Modelling will critically depend on whether the insurers and regulators have a true appreciation of the:

- Benefits of an IPCMF; which we have identified to be 1) a better understanding of the business written by senior management and underwriters, 2) more robust capital modelling outputs and 3) a stronger regulatory framework.
- Practical applications; and the positive influence an IPCMF would have on processes like account pricing, aggregation management, business planning, reinsurance purchasing or performance monitoring.
- Challenges and obstacles on the journey towards that implementation; such as the communication channels between the two functions, the differences in approaches, level of granularity and timing, and the technological resources.

Finally, we conducted a "Survey of Current Practices" in order tom offer the practitioner a broader perspective on the issue. This was based on the results of a survey we sent to general insurance actuaries, as well as the results of our investigations into the Life Assurance and Banking industries. Our main observations were that:

- Organisations are generally keen on integrating their Pricing and Capital Modelling functions.
- The main challenge to further integration is the lack of resources, in particular time.
- Internal opposition, where it exists, tends to come from senior management rather than Pricing or Capital Modelling teams.
- Large firms (with their extensive resources) and smaller firms (with simpler functions) seem to be better integrated than medium-sized organisations.
- Reinsurers are more integrated than, in turn, Personal Lines then Commercial the London Market insurers.
- Pricing assumptions have more influence on capital than capital assumptions do on pricing.
- Life Assurance seems to be fairly consistent in its approaches to Pricing and Capital Modelling.
- The Banking industry is fairly well integrated: the assumptions used on risk parameters and correlations are consistent, pricing uses capital requirements in its profitability calculations and feeds capital usage so that the company-wide capital requirements under the Basel II framework can be monitored.

1 Introduction

1.1 Objective of the paper

The objective set for our working party by GRIP was that of helping the Profession with one of its latest challenges: the Integration of Pricing and Capital Modelling.

In the last decade, actuaries have dramatically increased their influence in these two areas, but their work has sometimes evolved in different directions:

- Pricing is typically focused on the transactional level, and does not usually give much consideration to the aggregation of underwriting risks at the organisational level.
- Capital Modelling is typically focused on determining capital requirement for regulatory purposes, without aiming to impact daily underwriting decisions.

It remains that both model the same underwriting risks, and there is therefore mounting pressure to integrate these two processes so that they produce a single, consistent picture of the business, albeit with different levels of granularity.

The pressure comes from Management who would like to reap further benefits and synergies from their investments in actuarial models; and from the Regulator, in particular under Solvency II, who would like to see both processes embedded within the business.

Actuaries are therefore at a crossroads. While the long-term goal is clear, there is unfortunately only little guidance on which path to follow. Our working party has taken on the challenge of exploring various visions for an Integrated Pricing & Capital Modelling Framework (which throughout this paper we refer to as an "IPCMF"), and offering practical recommendations to make Pricing and Capital Modelling work in tandem.

1.2 Recommendations from GRIP

The impetus for this working party came from one of the recommendations made by the General Insurance Premium Rating Issues Working Party ("GRIP"). It wrote that "as part of the FSA's new solvency regime, most insurers have developed stochastic models as part of their ICA submissions. It is the FSA's preference (and indeed good business practice), for these models to be integrated within the business. Part of this integration involves having consistent assumptions within the stochastic model and any pricing models (or at least assumptions within the capital model that are prudent compared to pricing models), including things like (…). Many insurers have just completed the first integration of building capital models, and an important next phase is to complete this integration."

GRIP wrote its paper during 2006, so by now UK insurers are in the second or third round of ICAS and it is hoped that most are well on with the integration phase. The FSA's guidance reflects this passage of time, with an increasing emphasis on the embedding of the ICA model with other business areas. Meanwhile Solvency II discussions continue apace, with the prospect that its embedding requirements will be more demanding than ICAS.

In the context of all this, this paper has widened GRIP's suggested topic from "Integration of Pricing with ICAs", with its relevance just to the UK until Solvency II, to "Integration of Pricing with Capital Modelling", with relevance beyond UK and beyond Solvency II.

GRIP's own brief had been to identify areas where actuaries might be able to improve their contribution, to identify areas where methods and approaches could be improved, and to consider how improvements could be made to the way pricing actuaries communicate. Its other terms of reference, including the suggesting of areas of research such as this paper's, followed from these main aims.

We have tried to stay faithful to this guidance, in particular by discussing the problems with and opportunities for better communication between the pricing and capital areas.

1.3 Evolution in Capital Modelling

The idea that insurers can benefit from integrating Pricing & Capital Modelling is only conceivable because Capital Modelling has evolved dramatically in the last decade and is now firmly established within the UK insurance industry.

First, there is an incentive to invest in robust Capital Modelling in order to manage regulatory capital requirements efficiently. Second, many organisations have embraced the concept of economic capital and use it to drive their strategic decisions.

1.3.1 Regulatory framework

The FSA introduced ICAS because it was not prepared to wait several years for Solvency II, and because it wanted to ensure that UK insurers would be well placed for the latter. In the first round of ICAs, it placed its emphasis on firms getting the numbers right at the FSA's chosen risk level (99½% VaR[1] over one year), and it concentrated its challenge on inadequacies in the risk identification and modelling.

For the second round of ICAs, however, it is focusing much more on embedding aspects of the capital model at the firm's own risk appetite, given the increasing realisation of the importance this will play in Solvency II. The FSA's Oct 2007 sector briefing warns that "it has interpreted ICAS requirements flexibly to allow firms gradual development, but it is likely that the rules under Solvency II will reduce its ability to offer this level of flexibility".

Discussions are taking place at this time as to what the detailed requirements of Solvency II should be, and the conclusions will be revealed in the near future.

1.3.2 Economic capital framework

Since the introduction of ICAS as a regulatory framework, many firms have spent time and money building and developing Capital Models. These Capital Models have been mostly technical and incorporated within the actuarial umbrella with the primary aim to determine the required level of capital for regulatory purposes.

[1] Value At Risk

Over time these models have matured and developed from a technical and process perspective. These developments have allowed the business to become more aware of the alternative uses of Capital Modelling. As management become more aware of the financial impact of their day to day and strategic decisions, they can make more informed choices. In addition, senior management have also become keen to see the "return on investment" after incurring the significant costs of developing and resourcing Capital Models.

There is also a need for these models to be consistent with the current business processes and be integrated rather than running as a stand-alone process. This ensures the model is robust and reflects the way in which the company operates.

This process of integration and "embedding" within the business is still in the early stages of development for most firms, however is rapidly changing as the industry becomes more focussed on capital issues.

The economic capital framework has changed substantially over the past five years. However, with Solvency II being introduced and the increased knowledge of capital modelling and its broad usage within organisations, the economic capital framework will continue to be more widely used and also be more effective in modelling the financial characteristics of an organisation.

1.4 Structure of the paper

The structure of the paper reflects our objective to offer practical recommendations to actuarial practitioners facing the challenge of integrating Pricing and Capital Modelling within their organisation:

- Section 2 "Our Vision for an Integrated Framework" attempts to help identify principles and standards for an IPCMF, and determine what integration would look like in practice.
- Section 3 "Benefits, Practical Applications & Challenges" discusses the incentives to promote integration within the organisation but also the practical pitfalls and difficulties in doing so.
- Section 4 "Survey of Current Practices" contains the results from the survey we sent to practitioners, as well as the results of our investigations into the Life Assurance and Banking industries. It is aimed at offering a broader perspective on the issue.

We have tried to make this paper as generic as possible, so that it can be applicable to a wide range of non-life insurance organisations. We recognise, however, that there are a number of implicit assumptions in our approach. For instance:

- We have differentiated Pricing and Capital Modelling as two different functions but acknowledge that they can be performed by the same team in certain environments.
- We have assumed that Pricing deals with individual "transactions" but acknowledge that practice varies from pricing "contract by contract" (e.g. treaty reinsurance) to pricing structures by class of business (e.g. personal lines).
- We have also assumed that both Pricing and Capital Modelling were driven by actuarial models, although this is not always the case in all insurance environments.

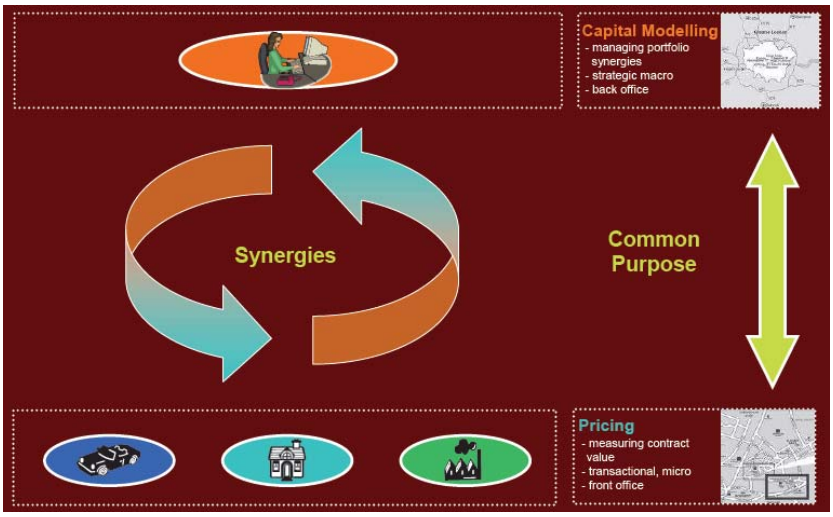
We trust the reader will be able to interpret our findings and convert them into useful guidance within the environment he or she operates.

2 Our Vision for an Integrated Framework

2.1 Introduction

Pricing and Capital Modelling can be considered to be "two different maps of the same territory, with different levels of granularity" as they both model the underwriting portfolio which is the sum of all transactions.

On the one hand, Capital Modelling deals with modelling the portfolio as a whole and focuses on the "macro" or strategic questions: where should we deploy our capital? should we raise more capital or return it to shareholders?...



On the other hand, Pricing deals with modelling individual contracts and focuses on the "micro" or transactional level: should we or should we not write this transaction?

The challenge for insurers is to align those two processes behind a common purpose, and create synergies whereby pricing helps deliver better capital modelling, and capital modelling helps deliver better pricing.

In this section, we have attempted to identify the main elements of an integrated Pricing and Capital Modelling framework. Our objective was to provide the reader with an overall vision for an efficient interaction between the two functions, as well as a set of precise criteria to gauge how integrated a particular organisation is.

We have concluded that an IPCMF would demonstrate five qualities:

- Consistency in methodology, assumptions and data.
- Pricing outputs designed to feed into Capital Modelling.
- Capital Models guiding Pricing decisions.
- Effective communication flows between Pricing and Capital Modelling.
- Embedding within the organisation.

2.2 Consistency in Approach & Assumptions

2.2.1 Common purpose

An essential part of an integrated framework is that both Pricing and Capital Modelling have a common purpose or, in other words, that they align behind an underwriting strategy based on the insurance principles of developing a portfolio of risks, and benefiting from mutualisation and diversification.

While this seems rather obvious, it should be contrasted to the way many companies currently operate:

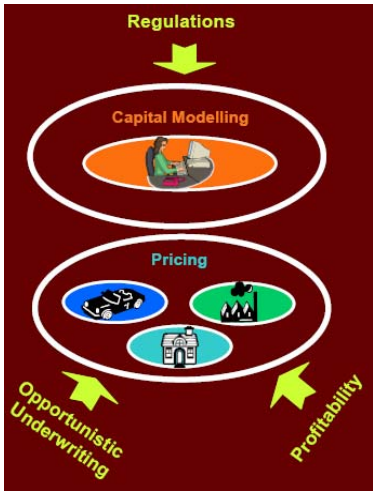
- Underwriting is opportunistic, for instance a contract is written if it meets a certain hurdle (e.g. lower than 90% combined ratio) without regard to the overall portfolio.
- Capital modelling is an aggregation exercise undertaken for regulatory compliance**.**

This purely opportunistic approach to underwriting does not explicitly recognise the benefits of mutualisation and diversification.

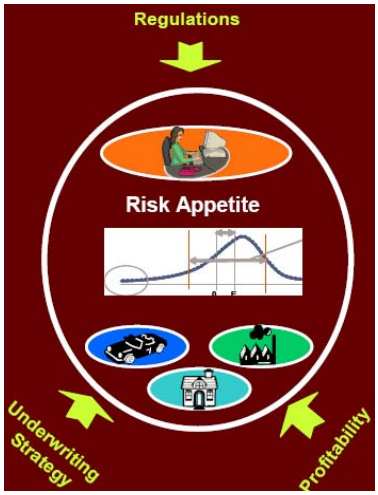
Capital modelling can only be used effectively for decision-making purposes if the underwriting strategy has a "portfolio dimension".

A strategy based on managing a portfolio means that underwriting decisions are based on the marginal impact the transaction has on the portfolio, and how the results fit with the profitability targets and risk appetite.

Opportunistic Underwriting Strategy



Portfolio Underwriting Strategy



2.2.2 Consistency in assumptions

An integrated framework would lead to consistency between the assumptions in the Capital Model and those in the Pricing model. For example, the distribution of aggregate claims derived for the capital

model would feed into the capital charge in the premium, or into the reinsurance charge if the firm buys protection for the accumulation risk.

It is common for the analyses of different departments to be used to make decisions. The use of inconsistent assumptions between analyses can distort the decision-making process and the overall conclusion reached. This could be important when optimising the trade off between risk and reward.

Consistency does not however mean identity – it would be acceptable for the assumptions to be different provided the reason for the difference was understood and documented. For example, the Capital Model may not be at the same level of detail as a risk being priced and therefore a common assumption about a collection of classes may be sufficient for the Capital Model, but for pricing an individual risk the most appropriate distribution would need to be chosen. For example, a large loss model using a Generalised Pareto may be used in the Capital Model, whereas a Log Logistic may be used in Pricing. Another example is the use of differing discount rates for pricing different classes, whereas the Capital Model may use a consistent discount rate from an economic scenario generator across the entire business.

There is a need for effective communication between the teams for identifying assumptions that should be consistent. As a by-product this may unearth nuggets of information that previously neither side was aware. By using an integrated framework, there would also be greater validation and challenge of the assumptions used in each area.

When attempting to get consistency between teams it is important that the assumptions from one team are not used blindly by another without understanding how they were originally intended to be used.

2.2.3 List of assumptions requiring consistency

We have discussed the need for consistency above. Rather than listing which assumptions should be consistent, it is easier to consider the concept from grass roots and identify which assumptions exist within the actuarial arena. From here, we believe firms should allocate 'assumption owners' who ensure consistency exists where required. The owner would then be responsible for determining what consistency means for any particular assumption, given the comments above about consistency not implying identity.

This concept relates to a larger company where different people may be responsible for different assumptions. However it would not be difficult to adapt the following list to any size of organisation.

Pricing remit	Attritional loss ratios (future and current)
	Large loss ratios (future and current)
	Large loss and CAT distributions (from RI work)
	Account pricing assumptions / data
	Reinsurance recovery / reinstatement assumptions
	Claims inflation assumptions
	Rate indices
Capital / Risk remit	ICA / Solvency II capital figure
	Total capital pot to allocate for pricing

	Capital allocation assumptions and split
	Target loss / combined ratios
	Required return on capital
	Correlation matrices
	Attritional coefficients of variation
	Economic Scenario Generator
	Interest Rate Assumptions
	Risk appetite
	Risk register
	Operational and other non insurance risk estimates
Reserving remit	Attritional loss ratios (historic)
	Large loss ratios (historic)
	Claims development patterns
	Cashflow patterns
CAT Team	CAT modelling output
	Realistic Disaster Scenarios

In our proposed integrated vision, all of these assumptions become interchangeably used within the different actuarial functions. The design and complexity of the pricing or capital models dictate the extent of cross-over within a particular company. For example, a more complex pricing model with variable risk loads may make some use of correlation matrices. To this end, the above assumption-owner approach can adapt more fluidly no matter the level of department integration.

2.3 Pricing Designed to Feed into Capital Modelling

2.3.1 Parameterisation of UW Risk

The underwriting risk component of Capital Models is typically parameterised by analysis of historic loss ratio volatility over time. Usually, loss ratios get adjusted for rate changes and claims inflation to restate on an "as-if" basis. The capital model would then assume that future year loss ratio would come from some distribution (e.g. Lognormal) with parameters derived from analysis of prior year adjusted loss ratios.

There are a number of issues with this approach:

- Parameter Risk: when looking at historical data, there is a time lag before data can reflect portfolio changes. Changes in underwriting philosophy and claims/market environment might mean that historic volatility and correlations between lines of business have evolved. The time lag in data may not be a problem if the book and risk profile have been stable over time; but it could be a major concern if the company is writing more volatile business than previous years, and the capital requirement calculations could be understated.
- Process Risk: catastrophic events may not be reflected in the historical data as return periods for such losses are longer than the time period considered. This could lead to the actual risk being understated. For example, some lines of business might not have claims

for ten or more years, but when a claim occurs the account would have a large spike in claims experience relative to premiums. A model that does not correct for this would lead to incorrect conclusions when assessing capital requirements and capital allocation.

These issues can be mitigated by taking advantage of the Pricing analyses, and using them to parameterise the underwriting risk component of capital models.

In our vision, Pricing actuaries provide detailed information on the expected profitability distribution for each transaction, which can be extrapolated for the more infrequent events. While their analyses are often based on historical claims and exposure information, they also enable the following to be integrated:

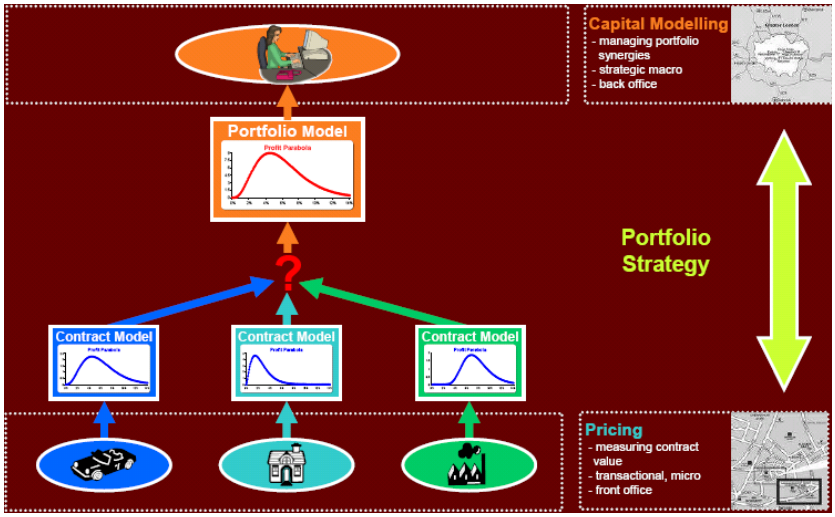
- Prospective assessment of exposures, e.g. from catastrophe models or other exposure-based information.
- Detailed information on trends and new developments in the market.
- Inputs from underwriters and other market experts.

2.3.2 Centralised models for systematic risks

In our vision of an IPCMF, Pricing analyses provide Capital Modelling with all the inputs necessary to the modelling of the portfolio. This means not only the expected profitability distribution for each transaction, but also how that profitability relates to the profitability of the other transactions in the portfolio.

With the exception of property catastrophe, the current practice is for Pricing to aim at determining the expected profitability distribution for each transaction.

Capital Modelling then attempts to aggregate the various distributions, by assessing how they correlate with each other.

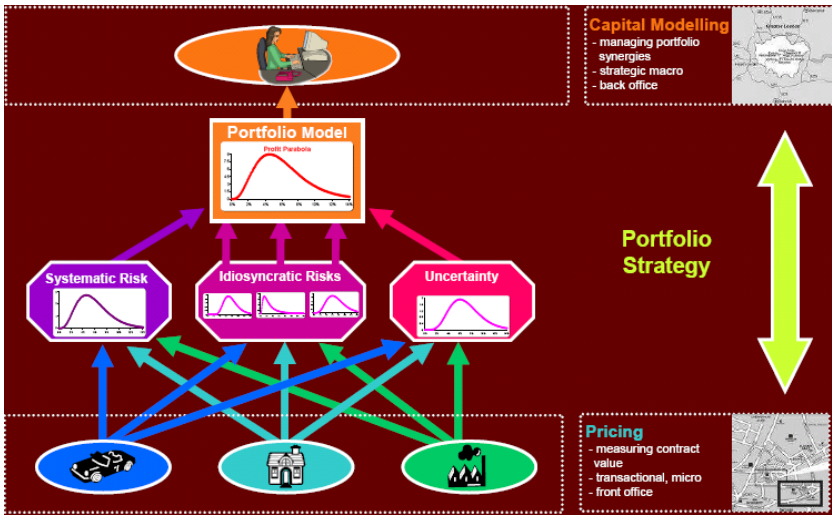


The estimation of correlation structures between transactions is a notoriously difficult task, and often provides “guesstimates”, a poor proxy for the real dependencies between transactions.

An IPCMF may therefore require a shift in Pricing practices, from the current transaction-based approach to one revolving around centralised models for systematic risks along the lines of the approach currently used for property catastrophe. This approach breaks down the Pricing analysis into various vectors of risk:

- an "idiosyncratic component", reflecting the risks specific to the transaction and independent of other transactions; and
- one or several "systematic components", reflecting the risks shared with other transactions in the portfolio.

For instance, a workers compensation policy may be priced as the combination of several systematic risk vectors (e.g. legislative benefits change, medical inflation, natural catastrophe, terrorism etc) plus an idiosyncratic risk vector. We would expect each systematic vector of risk to be modelled centrally, in order to ensure consistency between transactions.



In practice, firms can use a variety of approaches depending on the information available; these range from complex stochastic models to more basic realistic disaster scenarios.

These models would cover systematic risks such as: changes in liability legislation, landmark bodily injury court awards, corporate scandals, financial crises, widespread professional malpractice or mis-selling etc, which can affect many policies in several classes of business (and potentially the asset side of the balance-sheet).

The introduction of centralised models for systematic risks would not only strengthen Pricing analyses but, more importantly for the point of view of integrating Pricing and Capital Modelling, it would also greatly improve the robustness of Capital Modelling assumptions, in particular in the tail of the distribution where dependencies between transactions are critical.

2.4 Capital Models Guiding Pricing Decisions

In our vision, Capital Models would influence Pricing decisions via:

- Allocating capital at the line of business or individual transaction level.
- Setting a target return on allocated capital for each transaction, which optimises the insurer's expected profit in the current market conditions.

2.4.1 Capital allocation

It is worth noting that we have chosen not to discuss the technical aspects and practical pitfalls of capital allocation in this paper, as a specific working party has been set up for this purpose following GRIP recommendations.

Property catastrophe

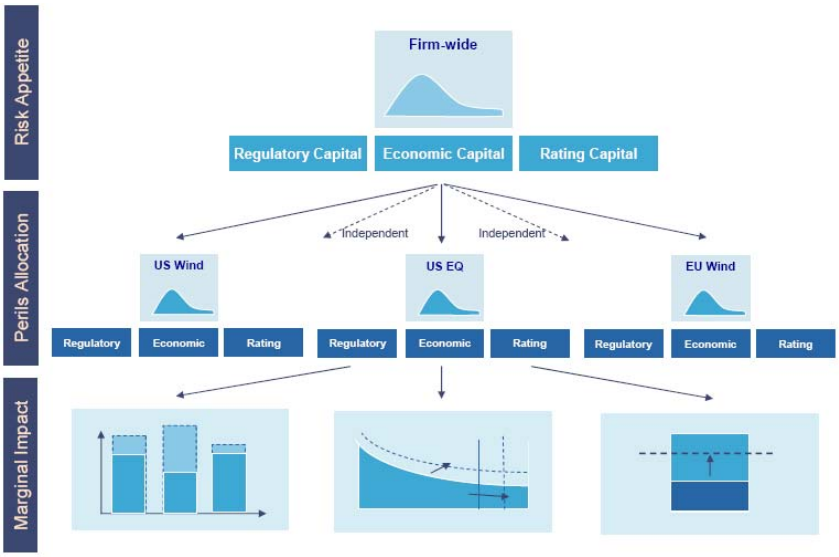
Capital allocation has been the most successful in property catastrophe, and it is often used as an example of a class where underwriting is done at the portfolio level rather than individual risks, using risk-based pricing and capital allocation to drive underwriting decisions.

In practice, the actual capital base of the company can be allocated down to individual independent perils such as US Wind, US Earthquake, European Wind etc, and converted to a risk metric (e.g. VaR, tVaR)…

The capital allocation for each transaction is then calculated as the marginal capital required to support that transaction based on the risk metric. This way, the targeted return on each transaction is consistent with the targeted return on capital for the company as a whole.

In practice, the actual capital base of the company can be allocated down to individual independent perils such as US Wind, US Earthquake, European Wind etc, and converted to a risk metric (e.g. VaR, tVaR)…

The capital allocation for each transaction is then calculated as the marginal capital required to support that transaction based on the risk metric. This way, the targeted return on each transaction is consistent with the targeted return on capital for the company as a whole.



Extending to other classes

We have identified three main reasons why the property catastrophe market has been successful in this area:

- Catastrophe models provide tools to model risks and their interactions and interdependencies, without relying on correlation estimates.
- This class of business is short-tailed, which means that losses have a direct impact on the balance sheet and reserving risk is limited.
- Participants in this market believe in the value of an IPCMF, have invested in the infrastructure and created a competitive advantage for themselves.

From this observation, we can see that the critical factors to extending this approach to other lines of business are:

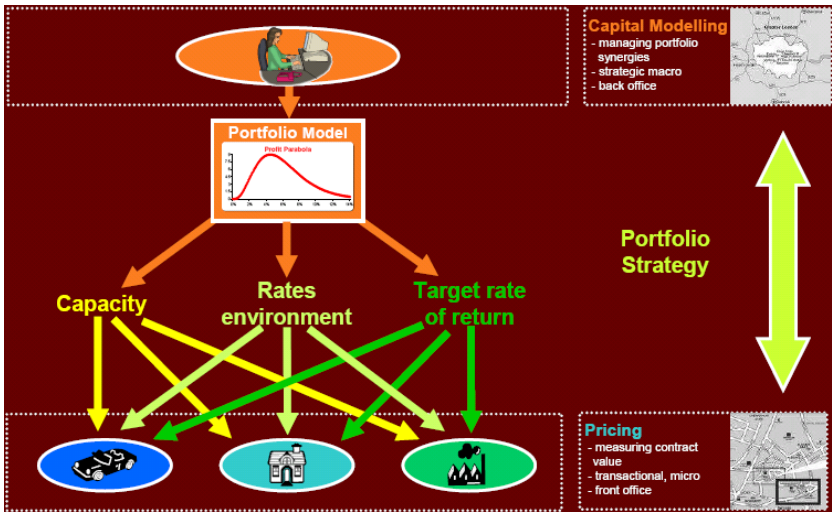
- Developing centralised models for systematic risks to overcome the need to rely on correlation estimates.
- Allocating reserving risk to individual transactions.
- Reconciling 1) the company capital requirements in respect of reserving risk, which are based on reserves from business written in prior years; with 2) the capital allocated to support individual transactions in respect of reserving risk, which affect company capital requirements over the run-off of the transaction. We note that the development of IFRS Phase 2 will help by promoting the recognition of profits over the run-off of the portfolio.

2.4.2 Target returns on allocated capital

In an IPCMF, the target return on allocated capital for each transaction should also help to transfer the results of the Capital Modelling work into Pricing analyses.

At the portfolio level, Capital Modelling has access at given points in time within the year to the following information, which could help adjust and optimise the company's pricing strategy:

- The remaining capacity available within the organisation.
- The rate environment.
- The expected demand flow for the remaining period.



This information can be converted into a target return on allocated capital, designed to optimise the company's expected profit in response to the market conditions.

These techniques, often labelled Revenue Management, are successfully implemented in other industries like airlines, hotel chains or internet service providers. Those industries are characterised by a fixed, perishable capacity (i.e. it is lost if not used during the time period), which is a good description of insurance capacity in the short term.

For instance, airlines use sophisticated revenue management systems based on historical booking patterns to estimate the likelihood of an empty seat at departure. They need to balance the risk of not selling that seat against the opportunity cost of undercharging a "premium customer" willing to pay a higher price: "If a plane is not filling up as rapidly as historically expected, the probability of an empty

seat goes up and the opportunity cost of selling more discounted seats goes down, so the airline's management system may offer some tickets at an exceptionally low price. If, however, a group of seven business people suddenly books onto the flight, the probability of filling the flight jumps substantially, the opportunity cost goes up, and the airline's management system blocks additional sales of the cheapest tickets."

The price of an insurance transaction is effectively the target return on allocated capital, and a company could use Revenue Management techniques to select an optimum target return in response to market conditions.

2.4.3 Examples of interaction between/within lines of business

The Pricing actuary needs to know how much to add to the recommended risk price for a contract to allow for the cost of capital. Ideally this would be the marginal increase in the total capital required by the firm, but this exact cost could only be derived by re-running the capital model.

Since most firms run their capital models at most quarterly, the Capital actuary needs to derive not just the firm's capital requirement, but also capital loadings and marginal adjustments that can be applied to these loadings by the Pricing actuary without reference back to the capital model.

For example, if a firm writes a short-tail and a long-tail class, the loadings for the latter need to recognise the continued capital cost in subsequent years, arising mainly from reserving, credit and market risk, i.e. the risks that liabilities might deteriorate, reinsurers fail or assets lose value. Without this, the firm might wrongly expand the long-tail line rather than the short-tail line, or follow the long-tail line further than it should into a soft market. If the lines were commercial motor and liability, the loadings might appear as:

Capital loadings as at (date)	Low retention	High retention	Aggregate retention	Excess layer
Commercial motor – fleet	2.0%	3.2%	4.2%	6.5%
Commercial motor – CV	2.0%	2.6%	3.2%	-
Commercial liability – public	4.0%	5.5%	6.5%	9.0%
Commercial liability – products	-	6.5%	7.5%	9.0%

In this example the loading is applied to the risk premium which is primarily driven by the mean, so marginal adjustments are needed for business changes that alter the volatility relative to the mean, or that affect the diversification for the line of business concerned:

Ready reckoner of adjustment for:	Motor loadings	Liability loadings	Reason
5% growth in motor book	+ 0.1%	- 0.2%	Less/more diversification
5% growth in liability book	- 0.1%	+ 0.2%	More/less diversification
10% growth in all business	- 0.1%	- 0.1%	Non-linearity
1% interest rate rise	+ 0.2%	+ 0.5%	Capital more expensive
Economy less stable	+ 0.1%	+ 0.3%	Inflation more volatile

The marginal changes can only be applied to a limited extent because of non-linearity, and in practice the table above might have to specify limits within which the ready reckoner can be used, such as -10% to +20% for motor book growth. When the Pricing actuary needs to know the impact of a greater change, or of a change not covered by the ready reckoner, he/she would have to ask the Capital actuary to rerun the affected modules or, if necessary, the full capital model.

We note that if a firm is using more sophisticated capital loadings, such as an additional loading on the catastrophe part of the premium, this may be more robust against business changes and need fewer adjustments.

A firm might run its Capital Model in full once a year and after any major business change, and in addition run the various modules of which the Capital Model is formed periodically during the year. So if it writes property business, it re-runs its catastrophe module whenever a new version of its commercial catastrophe model is released.

Likewise it re-runs the market risk module after an investment shock, or the underwriting risk module for a particular business line after a substantive change within that line. Any resulting changes to the capital loadings or marginal adjustments are communicated to the Pricing actuary.

The above example assumes the firm's practice is for the Pricing actuary to recommend a theoretical price and to leave it up to the underwriter to adjust this for market conditions, based on general feel for the impact of refusing to follow the market down.

As models improve, we hope that more firms will allow the actuary input into this softer part of the decision, by modelling the cost of unused capital and idle resources, and the extra cost of regaining the lost business when the market turns. The ready reckoner would then need to contain adjustments to be applied when the firm has an alternative use for the capital, such as share buy-back, or for the resources, such as retraining staff for another group company, and perhaps for changes in customer loyalty.

2.5 Effective Communication Flow

2.5.1 The communication challenge

Regular communication between Pricing and Capital Modelling is a key component of an IPCMF. Even if the respective data and models are "integrated", if there is poor communication, there is a danger that

the modellers could misunderstand the business and uncertainties within the assumptions, leading to inappropriate use of and over-reliance on technical modelling to evaluate capital.

The communication challenge lies in translating knowledge and information from Pricing into a form usable in a statistical business model (ICA/economic model etc) and vice versa – discussing statistical concepts in ways that Pricing will understand and relate to, and using the output from Capital Model to inform better risk decisions.

A key component of information flow is using the information that the company bases its pricing on (be it statistical distributions or market experience) to parameterise or sense-check the underwriting distributions in the Capital Model. For instance, there would not be sufficient historical losses to quantify the tail of insurance large loss risk (probably even at the 1 in 20-year level, never mind the 1 in 200-year). However, a Pricing view on what might be expected to happen in the tail is useful to fill the gap.

Other areas where communication from Pricing to Capital Modelling is important include:

- Developing an understanding of how business has changed over time.
- Understanding any characteristics of lines which may not be evident in historical data.
- Developing a consensus view on modelling dependency, in both standard dependency modelling and where copulas need to be parameterised.

The results of the Capital Model should be regularly communicated back to the Pricing community. This should aid their understanding of the risk of the business they write and also allow the opportunity for a Pricing "sense-check" of the capital model results. Regular presentations on the Capital Model results may also help to establish a common understanding between the Pricing and Capital Modelling functions, which should aid further communication.

As a means of focusing the Pricing team's attention on capital, companies may choose to base Pricing's performance measurement (and perhaps remuneration) on it. A target such as risk adjusted loss ratio, taking into account the frictional costs of having to hold the capital to back the risks taken on by the underwriter, could be useful. Whichever targets or metrics are used, at a line of business or similar low level they should correspond and link back to the information provided by the Pricing teams.

A key challenge with this approach is having the communication channels and skills to be able to explain this clearly in ways that Pricing understands. The clearer the links between the capital and the information provided, the easier it is to generate sympathy within Pricing for the tasks, and for Pricing to allocate sufficient resources to the exercises.

A further communication challenge is to demonstrate how the line of business information provided and capital requirements fit in to the overall company result (e.g. allowing for diversification). The drivers of company-level capital would need to be described in terms of typical scenarios which would give rise to the capital level, and how they relate to the information provided by Pricing.

2.5.2 Example of communication flow

One method to transfer knowledge from Pricing to Capital Modelling is for Pricing to develop specific disaster scenarios that can be quantified in both frequency and severity. These can be combined with whatever large loss information exists historically to improve the credibility of the tail of the distribution. When creating these scenarios, there are a few key points:

- The scenarios should be as specific as possible. This assists Pricing teams in assigning a frequency/return period and a severity to each one.
- It is usually very difficult to assign specific return periods to events (usually far more so than the severity). Typically it is better to work in ranges (say 1/10 to 1/50, 1/50 to 1/100, 1/100 to 1/200 etc) and for modelling purposes take mid points of ranges.
- Often the people with the market knowledge do not have a statistical background, and so it is the job of the modelling actuary to ask questions in a way that the answers can be meaningful. For example the question "what is the event at the 1/200 year frequency" is not likely to be met with enthusiasm. A series of questions such as "what is a very bad event?", "has the event happened in the last 50 years?", "would you be surprised if the event happened in the next 50 years, the next 100 years?" is more likely to generate useful information which can be translated into "statistical speak".
- It is important to get input from all Pricing teams reviewed by the head of Pricing or an independent unit within the team. This helps to mitigate the risk that the process can be manipulated to draw attention to personal issues, or that there could be significant inconsistencies between scenarios.
- Once scenarios have been created by each Pricing team, they need to be circulated to the other teams, in order to pick up any secondary impact that should be included, e.g. on a property damage scenario there could be additional liability/BI that wasn't picked up in the original estimation.

2.5.3 Data and information flow we would expect to see, and how used

The flow of data between departments will be specific to the structure of an individual company. It may be beneficial for a company to keep a database of key assumptions with their owners in order to promote an integrated approach.

The following assumptions are candidates for usage by both the Pricing and Capital teams:

- Underwriting Cycle
  - → Pricing information on the current stage of the underwriting cycle and historic rate changes.
  - → Capital Modelling team projection of the future of the underwriting cycle.
- Choice of distributions
  - → Requires thought on the aggregation or splitting of distributions.

- → Large loss and catastrophe distributions may be known from work by the Pricing team on reinsurance.

- Allocated Capital
  - → The Pricing team can use allocated capital to calculate risk loads possibly at an individual contract level.
- Expected profit
  - → Used by the Capital team to calculate the mean to breakeven adjustment.
- Business volume and mix
  - → Pricing assumptions can be used to make the Capital Model more realistic by allowing for price sensitivities.
  - → Pricing knowledge on the change in mix of business within classes can be used by the capital team.
- Large Loss assumptions
  - → Extreme large loss analysis can be very important to capital. This analysis could be used to assist in large loss loading in pricing.
- Extent of correlation of losses between class of business
  - → The Pricing team may be able to add quantitative insight into the Capital team's chosen dependency structure between classes of business.
- Reinsurance metrics
  - → Reinsurance optimisation can be more easily achieved using reinsurance prices from the Pricing team combined with the capital savings for additional reinsurance cover.
  - → The Capital Modelling team would benefit from the Pricing team's knowledge of inwards reinsurance.
- Investment assumptions
  - → The Economic Scenario Generator from Capital Modelling can be used when allowing for investment return in Pricing.

2.6 Embedding… The Use Test

2.6.1 Criteria for an embedded process

The FSA's Oct 2007 Insurance Sector Briefing set out a timescale for a typical medium-sized firm going from no capital model to a model acceptable for Solvency II purposes. This envisaged that in the first year a firm would establish a basic model and in years 2-3 it would use the lessons learnt from this to construct a full model and then to refine it and its calibration. During this time embedding of the model would be low-key, just picking off the more obvious applications. In years 4-5, the firm would be expected to achieve wide usage of the model in its planning, pricing, reserving, capital allocation, internal and external risk reporting. At the same time it would use the reverse flow of information from all its business functions to refine the model calibration still further.

	Activity
Year 1	• Build first take model.
Year 2	• License a dedicated model platform. • Build model and use for ICAS.
Year 3	• Improve model calibration. • Apply more widely within the business.
Year 4	• Ensure wide usage in planning, pricing, reserving, capital allocation, internal and external risk reporting. • Improve model calibration.
Year 5	• Objective is for it to be embedded to an acceptable level. • Further development and calibration will continue as required.

The draft Solvency II Directive states that insurance or reinsurance firms wishing to use a full or partial internal model in the calculation of their Solvency Capital Requirement must submit an application to the supervisory authority. For approval to be given, the firm must demonstrate that its model satisfies five tests: the use test, statistical quality standards, calibration standards, validation standards, and documentation standards.

For the use test, the firm needs to demonstrate that its internal model is widely used in and plays an important role in its risk-management system and decision-making processes, and in its economic and solvency capital assessment and allocation processes. For the statistical quality standards test, the methods need to be based on adequate actuarial and statistical techniques and to be consistent with the methods used to calculate technical provisions. Also they need to be based upon current and credible information, realistic assumptions, and data that is accurate, complete, appropriate and updated at least once a year. For the validation standards test, the statistical methods need to be appropriate compared to loss experience and to all relevant new data and information.

There is no explicit mention in these extracts of basing the modelling on pricing data, but this is only because the Directive does not provide this level of detail. It would be difficult for a firm to argue that its model satisfied any of the above if it could not demonstrate that the calibration of its model made use of pricing data and that similarly the capital costs assumed in its pricing decisions flowed from its capital model.

We do not intend to speculate further here as to what the precise embedding requirements of Solvency II might be, as discussions are already taking place and the results should be made public in the not-too-distant future.

2.6.2 Examples of practical ways of achieving embedding

In order for a model to be "embedded" in the business, it must be aligned with business current processes and used for key strategic or management decisions in the running of a firm. There are many ways in which capital models can be "embedded" in the business, the below outlines a few practical examples of how this can be achieved:

- Capital Allocation: Capital Models are a useful way to allocate capital to line of business and improve underwriters' understanding of the true cost of their financial decisions. This is useful for business planning and performance incentives. It is also useful for senior managers to improve their understanding of the key capital users in the business.

- Business Strategy: Capital Models can be used in making decisions regarding mergers and acquisitions, writing a new line of business, transfer pricing or investment strategy. This allows senior managers in the business to make more informed decisions based on the impact on the business.

- Business Planning: an IPCMF can be useful in developing robust business plans which reflect underwriters' estimates of the business they expect to write and in turn make capital models more accurate through a feedback process.

- Outwards Reinsurance: the effectiveness and appropriateness of reinsurance programmes can be assessed and used as a tool for discussion with brokers and underwriters to determine the optimal programme to suit the business' requirements.

- Reserving: the variability of reserves can be assessed within the reserving process, with the output being passed to the capital model. This further integrates the capital model and enables better parameterisation and review.

- Catastrophe and Aggregation Management: aggregation of risk across the business can be assessed using a capital model and it is useful in understanding the business and where the inherent risks are.

3 Benefits, Practical Applications & Challenges

3.1 Introduction

In practice, the decision to integrate Pricing and Capital Modelling will critically depend on whether insurers and regulators have a true appreciation of both:

- The benefits and practical applications of an integrated Pricing and Capital Modelling framework.
- The challenges and obstacles on the journey towards that implementation.

We discuss these aspects in this section.

3.2 Benefits of an Integrated Framework

Building an integrated framework can be a challenge, however there are many benefits which can be seen integration and understanding flow through an organisation.

We have identified the benefits to be: 1) a better understanding of the business written by senior management and underwriters, 2) more robust capital modelling outputs and 3) a stronger regulatory framework.

3.2.1 Better understanding of the business

A structure where Pricing and Capital Modelling operate in silos makes it difficult for underwriters to understand how the business they write affects capital requirements, and for senior management to use Capital Models to promote capital efficient underwriting strategies.

An IPCMF will improve the linkage between strategic and day-to-day decisions, and should therefore help on both fronts:

- Underwriters should have a clearer picture of the key drivers of capital utilisation and financial performance.
- Senior management can test and gauge the impact of various underwriting strategies on capital requirements, before deciding which one to implement.

3.2.2 Robustness of capital modelling

Linking assumptions to underwriting decisions

An IPCMF means that Capital Modelling assumptions are better linked to the actual business written, rather than the business planning exercise. By relying on the detailed Pricing analyses, Capital Modelling will be able to be more refined in its assumptions and capture changes in the market environment which are often not easily reflected in business planning.

For instance, capturing the underwriting and changes in the rate environment can be a challenging, in particular for underlying rate changes for inwards reinsurance. Similarly, capturing the expected profitability and volatility of the various classes can benefit hugely from relying on Pricing analyses.

This way Capital Modelling assumptions become increasingly linked to the assumptions underlying the key underwriting decisions, the current exposures in the portfolio; and less dependent on historical projections relying on the implicit assumption that the past will predict the future.

Embedding with other processes

While the integration with Pricing enhances the robustness of Capital Models, we note that there are many other aspects of the 'Actuarial toolkit' that will benefit from being embedded with Capital Modelling:

- Reserving – Capital Models can indicate the level of contingency and cat load required for immature years of account.
- Planning – many assumptions used in Capital Modelling can be used to improve the business plan; and vice versa.
- Reinsurance Purchase – provides assistance with testing the suitability of the proposed outwards reinsurance programme, in particular assessing the potential benefits / costs for selected return periods.
- Catastrophe modelling – linkage of assumptions on likelihood and severity, plus level of premium / capital required for a Catastrophe occurring.
- Volatility monitoring – qualitative profile analysis of the business being written, which can be used to benchmark the capital allocations being produced by the Capital Model.

3.2.3 Strengthening of the regulatory framework

As noted above, the regulatory framework in the UK (and soon throughout Europe) has become more dependent on internal Capital Models, to provide indicators of the capital requirements for insurance organisations. In addition, the low return period for setting regulatory capital (i.e. the 99.5th percentile of the profit/loss distribution) means that the results can be very sensitive to the assumptions and the quality of the Capital Modelling undertaken by insurers.

There might therefore be a temptation for insurers to select their assumptions, in order to lower their capital requirements and hence increase the expected return to their shareholders. This has a significant impact on policyholder protection.

The integration of Pricing with Capital Modelling means that Capital Modelling assumptions would be linked and consistent with Pricing assumptions, which are derived independently of the regulatory framework to drive business decisions. We would therefore expect that an IPCMF would help the regulator assess the capital requirements for insurers.

3.3 Practical applications

Based on our working party's vision presented earlier in this paper, this section aims to highlight a number of processes which can be positively influenced by an improved level of integration. In each section below, we have attempted to use an example to guide the reader through the steps required to achieve their goals.

3.3.1 Account pricing

Tangible changes to account pricing would be worth pursuing.

In the main, this application focuses on setting a maximum combined ratio which is acceptable to meet an assumed target return on capital. This concept is suggested to be employed as a flat hurdle across different individual accounts in the short term. In the medium term, we have identified how this hurdle can start to be flexed by account using standard debit / credit systems.

An alternative path is going directly for variable risk loads by account. Again, structured on-the-spot underwriter modification may be a longer term adjustment to this to allow for features not included in the capital allocation or risk load calculation - this is to the extent that the company feels such amendments are necessary.

Communicating what these hurdles are, how they have been calculated and getting buy in, is a process which needs to run along side the technical implementation.

Account Pricing	Short Term	Medium Term	Long Term
Technical development	Begin introduction of hurdles in account pricing. Introduce referral process where risks do not meet hurdles.	Introduce standard underwriting credit system that affects hurdle combined ratio.	
		Develop and agree a technical method for variable risk loads (whether capital related or otherwise).	Begin trying to implement variable risk load calculations at a large policy / sub-portfolio level. Identify other underwriting factors by class which give 'risk load credits'.
Communication and culture	Communicate to product underwriters the purpose and calculation of hurdle rates.	Increase understanding across the wider underwriting community.	Develop underwriter understanding of marginal effects of a policy on capital.

3.3.2 Aggregation management

Once an embedded process has been implemented, the Capital Modelling team would be in an ideal position to monitor risk accumulations within and also across lines of business. The capital team would aggregate the systematic risk exposures provided by the individual line-of-business underwriters/pricing actuaries and would model possible loss scenarios that could arise from a specific loss event. An output from such a model could be the capital requirement arising from a severe systematic loss event, and could also provide insight into the most effective risk mitigation option (such as the most effective type of reinsurance).

For example, property underwriters could use catastrophe modelling software when pricing business with catastrophe exposure to calculate the required catastrophe load within the premium. For a

company with multiple underwriting teams, the various underwriters could provide a list of insured locations to the capital modelling team, who could run a model for the whole property class.

A similar approach can be used for other systematic exposure across the portfolio.

3.3.3 Business planning

A company could use the internal capital model as a tool for setting its business plans. The capital model would aggregate various inputs and assumptions with regard to premium rates, loss experience, investment income, etc. The output from such a model could provide management with a consistent picture of the likely premium volume and expected profit, in line with the capital requirement per line of business.

An integrated process can ensure that there is consistency within the business plan between current market conditions and the company's growth ambitions. This process could ensure management sets realistic goals for the various underwriting teams within the business.

This model can be updated at frequent intervals as actual experience emerges and used to explain differences between planned and actual numbers.

3.3.4 Reinsurance purchasing

The reinsurance function is one area naturally amenable to integration with capital modelling. The requirement to understand 'how bad things can get' is common to both lines of work and there are therefore some natural synergies.

A practical starting point is to get the Capital Modelling and Pricing actuaries involved with the ceded reinsurance discussions. Where reinsurers or reinsurance brokers are producing models, it should be possible to arrange discussions around assumptions and pricing.

The short term plan should be to encourage involvement and an improved understanding of the treaty if this does not already exist. As time progresses, agreement between internal actuaries and the reinsurance markets as to the pricing of these layers is a good sign of progress.

The level of detail required for a reinsurance pricing exercise is likely to be greater than for the capital model. A commonly cited option is to build sub-models specifically for reinsurance which can be slotted into the main model. This would improve the timeliness, accuracy and use of the reinsurance components. Running internal models alongside external (reinsurers or brokers) models with the same data and assumptions ensures that the internal models are working in sync with real models which affect reinsurance buying decisions.

Communication challenges should be less for reinsurance integration as reinsurance buyers are likely to be more familiar with the principles of modelling.

Reinsurance	Short Term	Medium Term	Long Term
Technical development	Develop and collate internal views of all assumptions required for reinsurance modelling. Review the strengths and limitations of current modelling for reinsurance.	Improve consistency between broker RI modelling assumptions and those internal to the company Develop reinsurance models by treaty.	Run reinsurance models along side the main treaty renewal process to not only assess most cost effective treaty, but also capital impacts.
Communication and culture	Communicate the benefits to reinsurance managers.	Get buy in of capital modelling for reinsurance purchasing and help inform reinsurance strategy.	

3.3.5 Performance monitoring

A key output and indeed target for an IPCMF would be frequent and useful management reporting. A report which should be introduced is one which sets out the capital figure by line of business. Communicating the number itself is just the first step, with the next being the introduction of Key Performance Indicators ("KPIs") which affect that figure in the same report.

KPIs in this sense would be things like premium volume, diversification credit, class volatility, CAT risk, etc… These KPIs should be selected such that there is a direct and transparent link between changes in their value and changes in the capital figure by line. This process can then be used to encourage buy in by allowing underwriting heads to change their allocated capital figure by altering the KPIs. As time progresses, this process can be refined to improve the selection and sensitivity of KPIs.

It is likely that culture and communication improvements will follow from intuitive and useful reporting. Though presentations will be useful, the ultimate change in culture will come from a report which affects business decisions.

Monitoring	Short Term	Medium Term	Long Term
Technical development	Establish which factors most affect the capital figure by line of business	Refine the KPIs to understand sensitivities to the capital figure (gross and net). Embed KPIs in a report to management with explicit calculations linking KPIs to capital	Create feedback loops on where KPIs are not considered important / accurate. Streamline the processes feeding into KPI calculation.
Communication and culture		Emphasise the relationship between the KPIs and the capital number and in turn the target combined ratios	Encourage business owners to manage their KPIs and therefore their capital.

3.3.6 Other applications

There are several other processes which benefit the strengthening economic capital models resulting from an integration with Pricing, for example:

- Discussions with rating agencies: the analysis, documentation and reports provide evidence of effective risk management of the insurance company. This could help maintain and improve the Enterprise Risk Management assessment from the credit rating agencies.
- Investment strategy: the late 20th century saw strong growth in the stock markets that had offset the impact of some of the insurance risks that have materialised in the past. In the

past two years, the stock markets have been quite volatile and there is expectation of downturn in the economy. These raise concerns about the profitability and security of all financial contracts that carry an investment guarantee. A charge for that risk should be made. This involves an assessment of the inherent statistical variability of the financial returns of the investments. Most sophisticated insurers have considered the assets they hold in relation to their liabilities for many years. An economic capital model will allow an investment strategy to be formulated that not only considers the trade off of risk and return of the assets themselves, but also in relation to other risks and cash-flows an insurance company faces.

- Risk appetite: whilst the main use of economic capital is to guard against major disasters and satisfy regulatory requirements, it is also important to safeguard profitability. Keeping too much capital in reserves hinders growth; accurate calculations of risks and capital requirements can actually release capital. There may be diversification benefits from assessing capital at a group level because some risks may offset each other. Economic capital models provide the full range of risks/returns results, allowing strategy to be formulated on where to use the capital. Companies, and their stakeholders, will have a better understanding of their appetite for risk, and where they are prepared to accept volatility in exchange for higher returns.

3.4 Challenges

The challenges facing the integration of Pricing and Capital Modelling include the communication channels between the two functions, the differences in approaches, level of granularity and timing, and the technological resources.

3.4.1 Communication

Firstly, unless the same team/person is doing both Capital Modelling and Pricing, there is a danger of misunderstanding between the two sets of people. This is partly because the 'language' used could be different, even between Actuaries. This is particularly important when assessing the terminology and detail of assumptions. Consistency is required; as is allocating responsibilities, definition and ownership of key assumptions.

This is not to advocate against separate teams, since having the same person/team perform both tasks can lead to circular validation as well as entrenchment of errors due to lack of peer review and alternative views / methods. There is also potential for conflict of interest if the same person is fulfilling both the Capital Modelling and the pricing functions.

In addition, there remains the challenge of explaining to management, plus other interested stakeholders such as underwriters and brokers, the different requirements and outputs from Capital Modelling and Pricing. Pricing tends to be more focused and immediate whereas Capital Modelling assesses the long-term picture and is more complex.

3.4.2 Difference in approach

There are (currently) fundamental differences between the approach taken between Capital Modelling and Pricing. As well as the issues of the level of detail and of timing (see next sections), the approach may differ in certain respects:

- Capital Modelling is focused on calendar year periods, whereas Pricing is on policy years. The result is that Pricing analyses in a particular year have implications over several years of Capital Modelling.

- The level of prudence within the assumptions may vary between Pricing and Capital Modelling. When data supplied by the broker is incomplete or poor, the actuary may make educated 'guess-timates' to complete the pricing task, often based on soft data or experience. Additionally, data for a given risk or portfolio may be inconsistent from one year to the next. However, Capital Modelling requires a greater level of long-term rigidity and parameterisation.

- Capital Models produce a result net of reinsurance, whereas Pricing will often consider the gross result initially. Therefore care must be taking when applying Capital Modelling assumptions and output for the outwards reinsurance programme which may not be consistent with the actual reinsurance available at the time a risk or portfolio is priced.

- There is a tendency in Pricing to focus on the underwriting and reserving risks. However, the Capital modelling also considers the operational, credit, market, liquidity, and group risks as well as the impact of diversification. Therefore the Pricing Actuary needs to consider how to incorporate all these additional loadings into the model.

- It should be borne in mind that the aims of Pricing and Capital Modelling are different. The former is looking to produce a best estimate result (with perhaps a range); the latter must generate an extreme result such as 1 in 200-year. Therefore care must be taking when utilising output from one in the other to ensure the correct timeframe and return period is being considered.

- Similarly another issue to consider when integrating Capital and Pricing models is that the former generally focuses on selecting distributions and parameters that fit the tail whereas pricing tends to concentrate on the body of the distribution. Furthermore pricing tends not to explicitly allow for parameter uncertainty, which is required in Capital Modelling.

3.4.3 Level of granularity

There are also differences relating to the level of granularity between Capital Modelling and Pricing:

- Pricing may contain very in-depth analysis of factors pertinent to a particular risk which may prove too detailed or heterogeneous for use in Capital Modelling. Conversely, Capital Modelling needs to make consistent assumptions across a portfolio of risks, which can include taking views on homogeneity which may not exist at a more granular level.

- The subgroups of data for Capital Modelling may not be consistent with reserving groups which in turn may vary from the level at which Pricing analyses are undertaken. This could produce correlation issues when amalgamating or splitting the data. A solution for this is to agree in advance both a mapping between the Pricing and Capital Modelling data groupings, and how much detail from the Pricing models is required for Capital Modelling.

3.4.4 Timing

From a timing perspective, the main challenge from using Capital Modelling output in Pricing is that the Capital Modelling data may be out of date as it is usually only run annually or biannually. A solution may be to adapt a Capital Model so that it can be partially updated more regularly. This could be done by only running the relevant parts of the Capital Model or by bypassing the more complex and time-consuming element; or by splitting the Capital Model into sub-modules. Where Capital Modelling output lags behind that available from a broker's submission, a decision must be taken on which to use.

On the other hand, the 'continuous' nature of pricing means that a view must be taken not only on the point in time at which to extract this data but also how often to update it within the Capital Models (and at what level of detail & accuracy) to avoid unnecessary re-runs that could produce immaterial changes to the capital requirements. Also, Capital Models are built using year-end reserves, premium estimates, etc, and using prescribed rates of exchange from Lloyd's. Therefore pricing data must be consistent with these requirements.

3.4.5 Technological resources

The following are technological challenges that may need to be overcome to integrate Capital Modelling and Pricing:

- Capital Models may be written in software that is incompatible with that used for the pricing models, so dynamic data exchanges may not be possible leading to slow or even inaccurate transfer of data from one system to the other.
- Running Capital Models more regularly and faster to support the Pricing function may be hampered by the lack of available processing power or network availability.
- Network architectures may be unsuitable.

Over time these issues will be dealt with by developments in technology and processing power (cf. Moore's Law), so current technological challenges should only be viewed as temporary constraints that will be surmounted. Of course, the models themselves will be advancing in complexity, delaying the rate at which the technology catches up.

4 Survey of Current Practices

4.1 Introduction

Having outlined our vision for an IPCMF, and discussed its associated benefits and challenges, this section reviews the current practices in this domain. Our objective was to gauge the extent to which Pricing and Capital Modelling are already integrated within the various types of general insurance business, and within other "sister" industries, namely Life Assurance and Banking.

For this purpose, we:

- Conducted a questionnaire-based survey among general insurance practitioners to assess how integrated Pricing and Capital Modelling currently are, and to take their views on the benefits and challenges of achieving further integration.
- Conducted a series of interviews with practitioners in Life Assurance and Banking, in order to see whether they could provide additional sources of inspiration for general insurers.

4.2 Results of our Market Survey

4.2.1 Description of the survey

Our survey was designed to:

- Gauge the current level of integration of Pricing with Capital Modelling, using the criteria defined in Section 2.
- Collect the views of practitioners on the challenges and benefits of integration.

The survey consisted of 18 questions in total, covering the following key areas: assumptions, timing, benefits, challenges and details on the respondent's organisation. While most of the questions were multiple-choice, we also included a number of open questions so that respondents could provide additional comments.

The survey was conducted via an electronic questionnaire distributed by Peter Stirling to all general insurance actuaries on the Institute's database and a total of 82 responses were received.

For each question, the responses of the whole sample were analysed to ensure that the maximum amount of data was used. In addition, respondents were grouped by size of organisation, line of business and overall level of integration to see whether any of these factors affected responses.

- The gross written premium income of the respondent's organisation (ascertained in Question 17 – "What is the 2007 Gross Written Premium Income of your area of your organisation?") was used as a proxy for the respondent's size of organisation. Organisations were described as: 'Small' if they had gross written premium of less than £500m; 'Medium' if they had gross written premium of £500m to £1bn; 'Large' if they had gross written premium of more than £1bn.

- Respondents were also grouped by line of business, based on their answer to Question 18 – "Do the following lines of business represent a significant proportion of the business written by your area of your organisation?" The groups were: personal lines, commercial lines, London Market and reinsurance. Most wrote more than one line of business, and were therefore placed in more than one of the above groups.
- Question 2 – "First of all thinking about the current level of integration" was used as a proxy for the overall level of integration of the respondent's organisation. Those who answered '1 – Not at all integrated' or '2' (on a scale of 1 to 5, where 5 was 'Fully integrated') were described as 'less integrated' in the analysis of some later questions.

Here is a quick summary of the profile of the respondents to our survey:

- 6% of respondents worked in a consultancy;
- 25% were in an area of an organisation employing 5 or fewer actuaries; 33% in an area with 6-15; 21% with 16-25; 21% with more than 25;
- 33% of respondents were from organisations classified as 'small'; 29% as 'medium'; 39% as 'large'; and
- 47% of respondents' organisations wrote personal lines; 87% commercial lines; 72% London Market; 52% reinsurance.

A complete version of the survey results is included in the appendix.

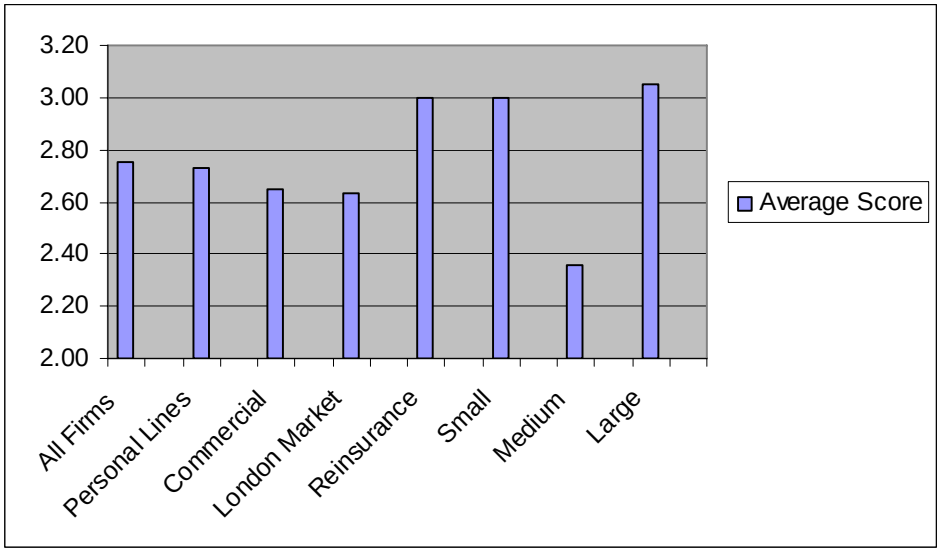
4.2.2 Key findings

- Organisations are generally keen on integrating their Pricing and Capital Modelling functions (particularly those that are currently behind in this area).
- The main challenge to further integration is the lack of resources (especially time).
- Internal opposition, where it exists, tends to come from senior management rather than Pricing or Capital Modelling teams.
- Large firms (with their extensive resources) and smaller firms (with simpler functions) seem to be better integrated than medium-sized organisations.
- Reinsurers are more integrated than, in turn, Personal Lines then Commercial the London Market insurers.
- Pricing assumptions have more influence on capital than capital assumptions do on pricing.

4.2.3 Detailed findings

Overall levels of integration

Question 2 asked respondents to rate the overall level of integration of their organisations on a scale of 1 to 5 (5 being the most integrated). The graph below shows the average response by size and line of business.

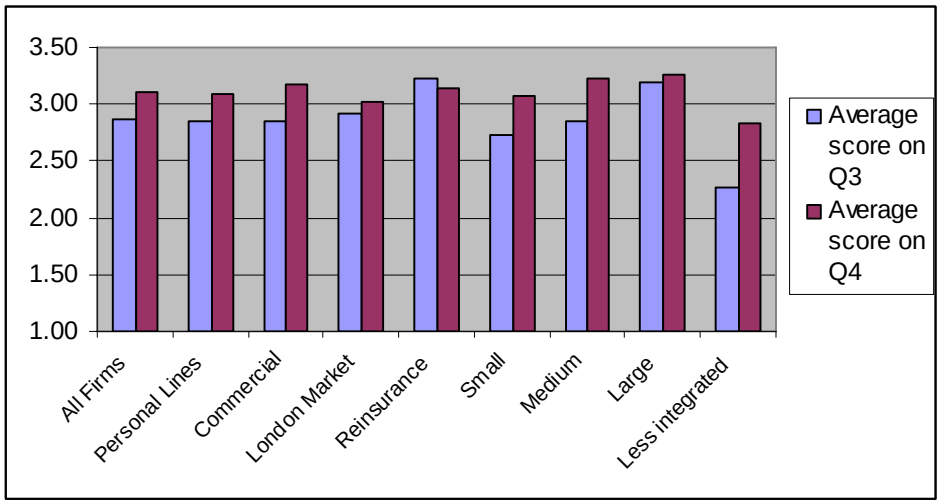


This suggests that reinsurers have slightly higher levels of integration than other firms. As reinsurance is often used as a proxy for capital, one would expect reinsurers to be more focused on capital management.

Medium-sized organisations seem much less integrated than their smaller or larger counterparts. This perhaps reflects the fact that they have more complex capital models than smaller firms, but lack the resources that allow larger firms to ensure integration.

Influence of capital modelling on pricing and vice-versa

Question 3 considered the impact of Capital Modelling on Pricing, while Question 4 considered the influence of Pricing on Capital Modelling. In both cases the influence was rated out of 5 (5 being 'fully integrated'). The graph below shows the average response by size and line of business.



In all cases except one, average scores on Question 4 were higher. Thus it seems that Pricing has more influence on Capital Modelling than vice versa.

Consistency of assumptions between Capital Modelling and Pricing

Respondents were asked to give the consistency of their Pricing and Capital models' assumptions a score out of 5. Overall, assumptions were fairly consistent, with an average score of just over 3.5.

The most consistent (with average scores of over 4) were:

- Return on capital targets.
- Outwards reinsurance protection.

The least consistent assumptions (those with average scores of less than 3) were:

- Increased limit factors.
- Tail correlations.
- Standard correlations.
- Contingency loadings.

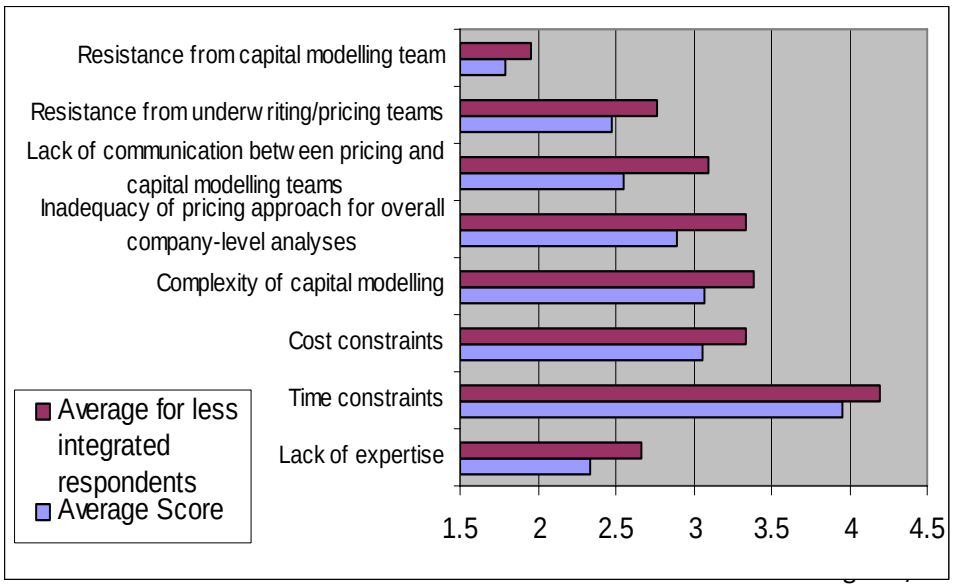
Small and large organisations, each with an average score of around 3.7, were slightly more consistent in their assumptions than medium-sized organisations, with an average score of 3.4.

Timing of pricing and capital reviews

More than half of the respondents review pricing annually, and most review capital annually. However, only 9% rated the timing of these two reviews as consistent. Given the time constraints, it is perhaps not surprising that organisations find it hard to conduct their pricing and capital reviews simultaneously, although this does increase the risk of out of date assumptions in an organisation's model.

Challenges to integration

Question 9 asked respondents to state the extent to which challenges to integration of Pricing and Capital Modelling exist in their organisation. The graph below compares the average scores (out of 5, where 5 is most challenging) for all respondents to the average scores for 'less integrated' respondents.



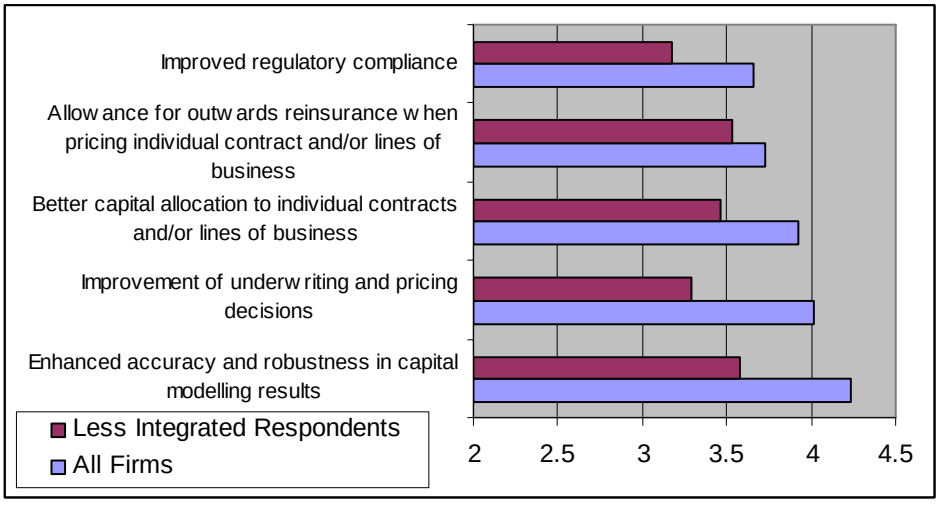
It is clear that the respondents with less integrated organisations are more concerned about all of the challenges of integration than the sample as a whole, with time constraints being the main obstacle to integration and resistance from the pricing and capital teams providing the least concerns.

The survey also asked the respondents for comments on any of the key challenges that they face. Respondents focused mainly on internal politics, especially the difficulty of getting support for integration from senior management. Below, two extracts are shown which illustrate the common theme from respondents who answered this section:

- "The key challenge is a political one. Decisions made as to the extent of integrated pricing and capital modelling across the group affect how the business develops in each area and in which direction. Resistance to placing these decisions in the hands of those performing the work by the team overseeing this integration has been apparent. Gaining confidence in the integrity and benefits of the integration is the main hurdle to be overcome."
- "It takes time to get senior management buy in and for it to filter down to Underwriters and embed in their pricing methodology."

Benefits of Integration

In Question 11, respondents were asked to consider the potential benefits of integration, with a score of 5 indicating they strongly agreed there would be benefits. The results are shown below.

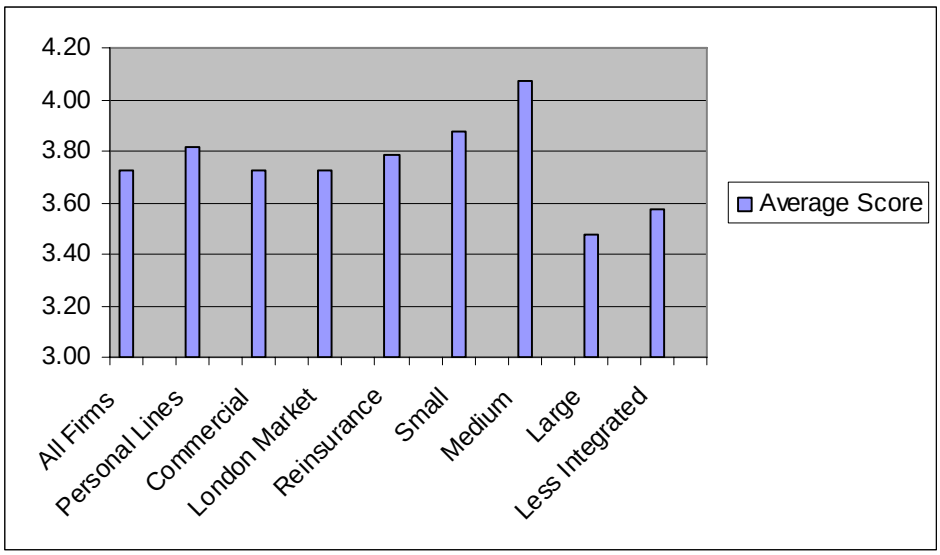


All respondents clearly felt there would be potential benefits for their organisations – the average score for all respondents is above 3.5 for each benefit, although the less integrated firms did not perceive benefits of integration to be as positive as their more fully integrated counterparts.

The survey also asked respondents if there were other potential benefits. Various improvements to the underwriting and pricing processes were cited, as were the benefits of showing consistency to management.

Q13 suggested that firms are broadly positive about the regulatory benefits of integration with large organisations being particularly enthusiastic.

The second part of Question 13 assessed whether the benefits of capital modelling outweighed the challenges (with a score of 5 representing strong agreement). The average scores on this question, by size of organisation and lines of business, are shown below:



It seems that most organisations believe that the benefits of integration outweigh the challenges – the average score for all firms was a strongly positive 3.7. Small and medium-sized firms seem to be more strongly in favour than large firms. Less integrated firms are still in favour of integration, averaging 3.6.

4.3 Practices in Life Assurance

4.3.1 Regulatory environment

The regulatory framework is based on the three "pillar" approach.

Pillar 1 sets out a valuation standard for liabilities to policyholders and the capital requirements firms will be required to meet for insurance contracts. Pillar 1 covers insurance, credit and market risk. Pillar 2 is the supervisory review process that focuses on evaluating the adequacy of capital and risk management systems and processes. Supervisors may decide a firm should hold additional capital against any risks not adequately covered in Pillar 1. Pillar 3 makes use of disclosures to harness market discipline by requiring firms to publish certain details of their risks, capital and risk management.

Pillar 1 consists of two peaks. The first 'regulatory peak' is a deterministic formulaic based approach that builds in significant prudential margins. Recently the required levels of prudence have been reduced following the introduction of PS06\14 and previous areas of significant prudence (such as lapses and expenses) can now be valued on a more realistic basis. The second or 'realistic peak' is only applicable for With Profits Funds (>£500m in size). This is on an asset share basis (such as a retrospective accumulation of premiums with investment income less claims less expenses) and includes

an allowance for the cost of options and guarantees. This is calculated using a stochastic model calibrated to current market conditions to evaluate cost of options and guarantees. Results are based on the mean of the distribution of likely outcomes.

Pillar 2 brings in the ICA calculation which is based on a best estimate basis with additional risk based capital to cover a 1 in 200 year event (over a 1 year time horizon) after assessing all of the risks to which the company is exposed. The FSA can, of course, make its own assessment of the capital requirements of a firm and set an ICG that exceeds the ICA.

4.3.2 Pricing & Capital Modelling practices

Historically life companies have used the "regulatory peak" capital requirements in their Pricing basis. More and more companies are now beginning to take account of the interaction between the regulatory and "realistic peak" when pricing, although this is only applicable for With Profits companies. Companies are also beginning to make allowance for the interaction between the Pillar 1 and Pillar 2 capital requirements in pricing. Due to the stochastic nature of the risk based capital calculations the projection of Pillar 1 peak 2 and Pillar 2 capital requirements has to be simplified for pricing purposes and companies are doing this by using the key risk drivers to project ICA capital over policy lifetimes.

Life Insurance companies have to hold the higher of all of these figures for their capital.

Life companies' ICA models are based on a ground up approach with capital required at a contract by contract level. However, diversification (which reduces the capital required) is allowed for between portfolios, at the company and group level. Similarly, in instances where the actual regulatory capital held under the three pillar approach is higher than the Pillar 2 ICA figure, this additional capital is not broken down on a contract by contract basis. As such, allocating the actual regulatory capital held down to an individual contract level for pricing purposes may result in inconsistencies with the ICA model assumptions.

It is quite common for Life companies to derive the ratio between their ICA and regulatory capital requirements at a given point in time. Future estimates of ICA requirements can then be approximated by taking this ratio of the modelled future regulatory capital requirements (which are considered to be easier to model). For some risks other more appropriate metrics such as sum at risk or premiums in force can also be used following this method to project the risk based capital.

4.3.3 Observations

Key Pricing assumptions (e.g. mortality rates) are generally consistent with the ICA model. However, there may some instances of out of date Pricing assumptions being used in the ICA model due to Pricing and ICA model reviews not being performed at the same time.

A key issue arises as a result of Life companies using "Embedded Value" reporting. The "Embedded Value" reporting measures the shareholders' interest in the company by considering the net shareholders' assets retained in the company plus future profits to shareholders from business in force at the current date. This values the company at an overall level and hence the level of sophistication of the modelling and assumptions used has to be more simplistic than that of the pricing models.

Embedded Value is an important metric for analysts and investors. So, for example, when considering a new life product, company management will consider the impact of a new product on the company's Embedded Value as well as whether the product is shown to be profitable under the more sophisticated pricing model projections. New products can be rejected if they are shown to reduce the company's Embedded Value even if they are actually shown to be profitable on a pricing basis. This highlights a key area in Life companies where the ICA model is not the ultimate decision making tool used in pricing although companies are now working towards embedding their risk based capital models within their business including areas such as pricing. The need to satisfy two bases can also lead to communication problems.

We note that there is a move in the Life industry going forward towards a market consistent Embedded Value approach which will lead to risk based capital being assessed on a contract by contract basis. This will act to resolve the problem referred to above.

4.4 Practices in the Banking industry

4.4.1 Regulatory environment

Banks are primarily regulated by the Basel II Accords, which are recommendations issued by the Basel Committee on Banking Supervision aimed at setting the international standard for local banking regulations. The structure of the Basel II framework is similar to the coming Solvency II framework, with 3 'pillars':

- Pillar 1 - sets out the mechanism for calculating minimum regulatory capital.
- Pillar 2 - identifies additional risk factors not captured in Pillar 1, giving regulators discretion to adjust the regulatory capital requirement against that calculated under Pillar 1.
- Pillar 3 - designed to increase the transparency of lenders' risk profile by requiring them to give details of their risk management and risk distributions.

In practice, Basel II attempts to ensure that banks hold capital levels appropriate for the risks they face from their lending and investment practices, namely credit, market and operational risks.

Since the assumption of credit risk from lending activities is the nearest in nature to insurance underwriting risk, it is the one that we have focused on.

Broadly speaking, the ratio of Capital to Risk Weighted Assets ("RWA") has to exceed a minimum capital ratio of 8%[2].

$$\frac{Capital}{Risk\ Weighted\ \ Assets} >= Minimum\ Capital\ \ Ratio$$

Banks have the choice between two approaches to calculate their capital requirements:

[2] This ratio may vary from jurisdiction to jurisdiction.

- Standardised Approach: RWA are calculated by grouping the banks' exposures into risk categories and applying prescribed risk weightings, either fixed or varying according to the external credit rating of the borrower. For instance, residential mortgages have 35% risk weight while BBB corporate bonds have 100%.
- Internal Ratings Based Approach:
  - → provided they can justify their basis, banks are allowed to develop their own estimates for the following parameters by risk category: probability of default ("PD"), loss given default ("LGD"), exposure at default ("EAD") and effective maturity ("M") [3].
  - → capital requirements are then derived by applying a pre-determined formula for each risk category.

In practice, banks of significant size use the Internal Ratings Based Approach.

4.4.2 Pricing & Capital Modelling practices

The capital requirement formula used under the Internal Ratings Based Approach has some interesting features, which facilitates its integration within Banks' pricing frameworks:

- The formula is based on an Asymptotic Single Risk Factor model (cf. Gordy (2003) and Basel Committee on Banking Supervision (2005)), which aims at estimating a "99.9%[4] 1-Year Credit Value At Risk", based on the parameter estimates.
- The model distinguishes:
  - → idiosyncratic risks, which are associated with individual exposures and can be diversified away.
  - → systematic risks, which reflect the macro-economic environment affecting all borrowers to a certain degree (calibrated via prescribed levels of correlations to the systematic risk by class).

Finally, the formula is portfolio invariant, which means that a given set of parameters (PD, LGD, EAD and M) leads to a single result for the capital requirement regardless of the rest of the bank's portfolio.

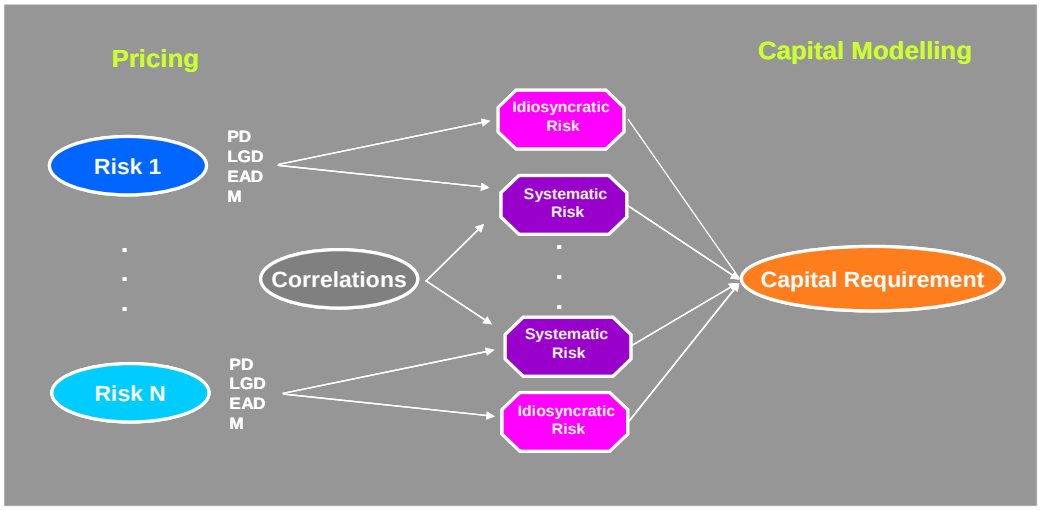
We interviewed practitioners in the banking industry who told us that the pricing or profitability assessment is typically done using an Internal Rate of Return Approach, with the capital requirements over time embedded within the process via the Basel II formula.

Conversely, the portfolio invariance property of the Basel II formula means that the capital requirements for individual exposures are additive. They are captured at the time of binding, based on the estimated

[3] We note that the IRB approach has 2 variants: under Foundation IRB banks are only allowed to estimate PD and the other parameters are taken from supervisory estimates; under Advanced IRB banks are allowed to estimate PD, LGD, EAD and M.

[4] This confidence level may vary from jurisdiction to jurisdiction.

risk parameter from Pricing (PD, LGD, EAD and M), to calculate the overall capital adequacy of the bank (they are also revised over time based on on-going estimations of PD, LGD, EAD and M). The graph below illustrates the overall process.



4.4.3 Observations

Pricing and Capital Modelling in the banking industry are fairly well integrated: the assumptions used on risk parameters and correlations are consistent, pricing uses capital requirements in its profitability calculations and feeds capital usage so that the company-wide capital requirements can be monitored.

A key factor in this integration is the Basel II capital requirement. The formula provides a proxy for the "99.9% 1-Year Credit Value At Risk", with the significant benefit of being both portfolio invariant and additive thanks to its separation of idiosyncratic and systematic parts of the risks.