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EDITORIAL

This editorial addresses the question: Is actuarial science really a science? In some universities the discipline is located, as a mathematical discipline, in faculties of science. In others it is treated as a branch of business economics. In practice, actuaries like to appropriate the best of both worlds by presenting themselves as experts in the relevant field both of business and of mathematics. But the question goes deeper than the location of teaching and research programmes or the self-image that the profession wishes to project.

The traditional, hypothetico-deductive approach to science is essentially a search for laws that reflect the truth about the world in which we live. It involves three types of scientific statements: statements of observation, empirical generalisations and hypotheses. Formally, a statement purporting to be a law is an hypothesis. Like hypotheses, laws cannot be proved. (Caws, 1965: 73–81)

In order for an hypothesis to be recognised as a law, it should unify the explanation of a range of different phenomena. This is a metaphysical statement, but it is arguably implicit in the traditional approach to science. Where the phenomena to be explained are a set of events (as opposed to a generalisation about the state of nature), the explanation requires reference to causes. Laws thus establish a symmetry between explanation and prediction, and may in fact facilitate the control of events. In order to be considered adequate, an explanation must:

– be a logical deductive argument;
– contain at least one law required in the deduction;
– be empirically testable (i.e. falsifiable); and
– comprise true statements. (Hempel, 1965)

Under this approach to science, a 'theory' is a set of hypotheses that is logically consistent and strongly supported by empirical evidence about the entities relevant to a particular field of inquiry and about their properties, some of which entities or properties are unobservable (i.e. 'theoretical'), and about the relationship between the unobservable entities or properties and the observable ones. Such hypotheses are in the form of laws constituting fundamental axioms, describing an unobservable underlying mechanism, from which empirical generalisations may be derived (such derivation constituting an explanation). It must be clear what statements of observation would falsify the theory.

This approach gives an apparently objective account of how a theory explains phenomena by 'uncovering underlying mechanisms'. This is clearly a metaphysical attraction. It is implied by a belief that the universe is fundamentally simple. "There is a true theory about layers of causal laws," the most basic being the simplest. The inference is that there is "a uniquely correct axiomatisation … that reflects the structure of reality." (Rosenberg, 2000: 80, 100)

But there are a number of problems with this approach (*ibid*.):

– Cause and effect cannot be observed. Because laws cannot be proved, cause and effect can also not be proved. The explanation is therefore not objective.

- Science has a bad track record of accepting laws that have been subsequently shown to be false. (While the risk of failing to reject a false hypothesis is unavoidable, the benefit of hindsight arguably suggests that scientists have been too ready to accept such hypotheses as laws.)
- There may be different ways to axiomatise the same set of statements.
- The logical derivation of the empirical generalisations operates on the formal syntax of the axioms and not on their meanings.
- Axiomatisation may prematurely freeze the development of ideas.

The modelling approach to science defines the concept of ‘theory’ quite differently. First, it defines a ‘system’ as a set of processes and relationships that exhibit regularity. A ‘theory’ is then defined merely as a specification or definition of an abstraction or idealisation of a real system. (Here an ‘abstraction’ is a system that is described in terms of a subset of the entities that are relevant to the real system, assuming that all others negligibly affect the behaviour of the system and an ‘idealisation’ is a system that allows entities that are relevant to the real system to attain values or states that would be impossible in that system.) (Craver, 2002: 65)

While the rejection of a theory may involve deductive thinking, the formation of a theory is a creative process involving lateral thinking. It is an essentially subjective process. A theory is not necessarily completely explanatory, but is generally at least partially interpretative in the sense that it must be subjectively meaningful.

The focus of this approach is on the ‘model’, defined as a representation of a real system in the form of a homomorphic system that satisfies or instantiates the theory.

The model is not isomorphic to the real system. This means that:

- the truth about the real system is unknown; and
- the degree of error in prediction and control is unknown.

However, this approach does not claim to achieve more than is possible. The model provides a useful calculating device for the purposes of prediction and control. Both the theory and the model are pedagogically useful. And the approach can accommodate approximations.

Kuhn (1974) defines a ‘paradigm’ as being ‘what the members of a scientific community, and they alone, share’. In its broader sense it comprises the entire ‘disciplinary matrix’, which consists of ‘symbolic generalisations, models and exemplars’. A ‘symbolic generalisation’ is a mathematical representation and a ‘model’ is a system that works in an analogous way to the system of interest. In actuarial science, the mathematical formulation of a model would correspond to Kuhn’s ‘symbolic generalisation’ and the running of the model on a computer would correspond to his ‘model’. For the purposes of this editorial it has not been necessary to distinguish between these two concepts, and the term ‘model’ has been used for both. Kuhn also uses the word ‘paradigm’ in a narrower and more fundamental sense to refer to a set of ‘exemplars’, which are defined as ‘concrete problem solutions, accepted by the group as, in a quite usual sense, paradigmatic’— typically the text-book examples given to students.

Introducing these concepts in the actuarial literature, Pemberton (1999: 122–3) explains Kuhn’s distinction between ‘normal science’, which operates within the paradigm, and the 'paradigm shift', which produces a revolutionary change from one paradigm to another. He summarises criticism of this distinction, particularly that of Popper (presumably Popper, 1963). But much of the criticism is directed at Kuhn's early work (specifically Kuhn, 1962) and does not take cognisance of his response to Popper (Kuhn, 1970a) nor of his later refinements (Kuhn, 1970b, 1974). In certain respects, Kuhn may have overstated his case. But his contribution to scientific discourse endures.

In its early days, actuarial science saw itself—and therefore defined its paradigm—as a 'science' in the traditional sense of the word. Mortality tables were not models of systems, they were particular cases of 'laws' such as those of Gompertz (1825) and Makeham (1860).

In the 20th century, actuarial science abandoned the language of laws (with the exception of the 'law of large numbers'; see below), but it held on to its self-image as a science, even though, for most of that century, the only understanding of 'science' was that of the traditional approach.

However, actuarial science clearly fits more comfortably into the modelling approach to science than into the traditional approach. While the latter approach does facilitate explanation and control of natural processes, both of which are required in actuarial science, its primary commitment is to the pursuit of truth for its own sake. Actuarial science, on the other hand (like certain other disciplines such as engineering and operations research), is more concerned with the practice of decision-making than with the pursuit of truth for its own sake, and the decisions that need to be made by actuaries or their clients must be made in an environment of uncertainty. As Pemberton (1999: 151) points out, "… actuarial science is not concerned with the development of laws." Instead, he argues (*ibid.*: 154):

> Actuarial science is concerned with the development of models which approximate the behaviour of reality and have a degree of predictive power …

and he identifies the focus of actuarial science (*ibid.*: 156) as being:

> very clearly upon developing models … to assist in institutional policy decisions.

If some of that uncertainty is uncertainty about the homomorphism between the model on the basis of which the decision must be made and the real world that it purports to represent, so be it. The decision must be made, and the actuary cannot wait until the traditional approach to science has formulated a theory that meets the standards of adequacy that that approach demands.

Models based on an idealised theory (such as the net premium valuation) have been used by the actuarial profession in the past. Such models may have explanatory value. But models to be directly used for outcome-orientated decision-making should be abstractions, not idealisations, of the real systems that they represent. Those systems may comprise processes and relationships (implicitly outside of the control of individual agents) that exhibit regularity; they may include rules, contracts, legal constraints and reasonable expectations that govern some of the processes and relationships involved; they may include elements that are subject to the control of the decision-maker and that affect some of those processes and relationships; and they may include the decision-making process itself.

In the past, the training of actuaries focused very strongly on techniques rather than models. Redington (1959: 2–3) explains that it was only after practising for many years that he perceived the difference:

> The habits of twenty years lay between me and the obvious: that the *amount* of interest income was a real thing outside myself, whereas the *rate* of interest by which it was valued was a product of my own mind.[1]

The idea of discounting to allow for future investment returns is second nature to actuaries, whereas to actuaries' clients, investment returns accumulate. In fact the client's perspective is closer to the mark. The actuary may fail to see (or at least to explain to her/his client) that the purpose of discounting liability cash-flows is to establish the amount of assets required to cover them—that discounting is merely the solution of an equation—for example by basing the rate used for discounting the asset cash-flows on a different risk-free rate from that on which the rate used for the liabilities is based. The equation of value actually involves a model of future investment returns. Bell *et al* (1998) recognise that the determination of a 'present value' is based on a model. Knox *et al* (unpublished: 4) go so far as to say

> … it may even be suggested that the specialised work of the actuary does not really start until [she/he] combines some or all of [the fundamental concepts of actuarial science] into a particular model to represent the problem at hand.

Nevertheless, the focus on the present value rather than on the model persists.

At times, the reference to the current actuarial paradigm as 'science' has served the interests of actuaries better than those of their clients' beneficiaries. For example, Redington (1982: 95) explains that his major reason for attacking bonus reserve valuations is:

> the continual references to such valuations as 'scientific'. This is a grave misunderstanding and a sad misuse of words. There is nothing scientific about bonus reserve valuations; on the contrary they are exercises in power. The difference is fundamental: the aim of power is to dominate, the aim of science is to understand.
>
> It is the same as the distinction between cleverness and wisdom.

It is noted that Redington uses the expressions 'to understand' and 'wisdom' rather than 'to know' and 'knowledge', which would be the more conventional interpretation of the aim of science. Wisdom, in particular, relates to decision-making rather than knowledge, and it requires more than knowledge. Certainly, even within the traditional approach, science aims to explain, and explanation creates understanding, and understanding facilitates wise decision-making; but the link between science and decision-making is tenuous.

In order for a decision to be described as 'wise', the criteria adopted for the decision must be wisely selected. In particular, the objective function must be wisely defined. What constitutes wisdom is, however, an essentially subjective question. Within the paradigm of actuarial science it would certainly include 'professional judgement', which in turn would include intuitive acceptance or distrust of a theory or model. Distrust of a

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1 Emphasis in the original

model may relate either to the structure of a model or to its parameterisation. It may arise either from the theory on which it is based or from the output it produces. In the latter case it would be necessary for the actuary to resolve the matter by establishing why the output is counter-intuitive, so as to decide whether to reconsider the model structure, the model parameters or her/his own intuition.

In the actuarial profession, the words ‘subjective’ and ‘objective’ are loaded with emotive meaning. Dyson & Exley (1995) recognise that ‘there is a large subjective element in any realistic basis [for the valuation of a pension fund]’. Pemberton (1999: 158) finds that:

> There would not appear to be any examples of effective modelling of specific financial situations which do not make recourse to judgement.

On the other hand, Exley, Mehta & Smith (1997) assert that:

> adoption of [a] market-based approach [to valuation] appears now to be essential in many of the most critical areas of actuarial advice in the field of defined-benefit corporate pension provision and … the principles can in addition be used to establish more efficient and transparent methodologies in areas which have traditionally relied on subjective or arbitrary methods.

Clearly the implication of such arguments is that, while subjectivity is inevitable, the degree to which actuaries rely on their subjective judgement should be reduced as far as possible.

On the other hand, the profession prides itself in its ability to use ‘professional judgement’, which is clearly subjective. For example, Milburn-Pyle (1995) states:

> Actuarial science … is a science of probabilities. This is the feature that distinguishes the actuary from other professionals in the financial arena. We are dealing with nebulous matters, and at the end of the day the actuary has to exercise judgement, based upon his assessment of the likely course of the variables involved. This puts him or her in a powerful position, because contesting another person’s professional judgement is not easy.

The Faculty & Institute of Actuaries defines a ‘profession’ as:

> an occupation in which an individual uses an intellectual skill based on an established body of knowledge and practice to provide a specialised service in a defined area, exercising independent judgement in accordance with a code of ethics and in the public interest.[2]

Knox *et al* (unpublished: 4) distinguish between ‘statistical estimates’ of model parameters and ‘actuarial estimates’:

> The difference is that the actuarial assumptions may allow for effects that are not necessarily observed in the data, or for future developments that have not been observed in the past.

It is clear from this that, while the necessity for subjectivity creates opportunities for actuaries to use their judgement, the profession has an obligation to roll back the domain of the subjective. Like other problem-solving professions, the long-term objective of the actuarial profession is to do itself out of a job. This naturally creates conflicting interests within the profession.

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2 http://www.actuaries.org.uk

Nevertheless, decision-making is essentially a subjective process. The decision-maker may rely to a greater or lesser extent on the actuary's judgement. But it is the decision-maker who must adopt a model in the face of uncertainty. And it is the decision-maker who must decide on the criteria to be used in the application of that model for decision-making purposes. For these purposes frequentist notions of probability are too restrictive. It is the decision-maker's subjective probabilities that need to be measured. Yet the 'law of large numbers' is still the basis on which probability is taught and understood within the profession (Bell *et al*, 1998). While Bayesian ideas and techniques were introduced into actuarial science in the late 1960s, the concept of a subjective measure of probability, which is essential to an understanding of those ideas, has not been adequately incorporated into the actuarial paradigm.

The concept of the 'actuarial control cycle' originally suggested by Goford (1985) was introduced into the educational curriculum of the Institute of Actuaries of Australia in the 1990s[3] and subsequently into that of the Faculty and Institute of Actuaries in the United Kingdom (Gribble, unpublished). This concept provides a framework for modelling in actuarial practice. The cyclical nature of the concept conforms nicely to Bayesian methods and to the modelling of subjective probabilities, but the integration of these ideas has yet to be pursued in the education of actuaries.

In recent years the major paradigm shift in actuarial science has arguably been in the quantification of risk: first in the treatment of investment returns as stochastic processes, and then in the adoption of the theories, models and exemplars of financial economics in the courses of study of the actuarial profession. This paradigm shift—like any other—has not been unopposed[4] and the profession continues to retain exemplars in conflict with the new paradigm.

It is clear from the above discussion that, if science is understood as a modelling process, actuarial science can comfortably claim to fall within its domain. That, of course, does not exclude it from the domain of business economics. The classification of this discipline as a science relates to its methodology. Its classification as a branch of business economics relates to its purpose.

This conclusion comes, however, with two provisos. If actuarial science wishes to remain a science, it must pursue the development of models that will facilitate decision-making in actuarial practice. And it must achieve greater clarity about the role of subjectivity in the development and use of those models.

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3 DM Knox & RHS Lyon. Educating Australian actuaries for the 21st century, *The Actuary*, October 1995, 28

4 See, for example, the debate on the motion: 'This house believes that the contribution of actuaries to investment could be enhanced by the work of financial economists', *Journal of the Institute of Actuaries* **120**, 393–414 (1993)

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