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THE NEED FOR THEORY IN ACTUARIAL ECONOMIC MODELS

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THE NEED FOR THEORY IN ACTUARIAL ECONOMIC MODELS

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ABSTRACT

This paper addresses the fundamental issues in the construction and use of actuarial economic models, with specific reference to those described in the UK literature. Two approaches are considered: an empirical approach and a theoretical approach using financial economics. Although empirical testing is essential, the difficulties associated with it should not be underestimated. A theoretical framework can be used to limit the impact of these difficulties. However, economic modelling is further complicated by the lack of a reliable and comprehensive theoretical framework. This suggests that economic models are always likely to be inaccurate and consequently actuarial judgement is likely to be indispensable.

KEYWORDS

Economic Methodology; Financial Time Series; Jump-Equilibrium Model; Stochastic Asset Models; Wilkie's Model.

1. INTRODUCTION

1.1 *Background*

1.1.1 This paper suggests a methodological approach for the development and application of actuarial economic models. This approach is based on Hausman (1992) and is formulated after discussing the methods used to construct the main UK models including Wilkie's (1995) model and Smith's (1996) jump-equilibrium model.

1.1.2 Actuarial economic models are generally derived and justified using the probabilistic structure of the historical data and using theoretical considerations, which are primarily obtained from financial economics. Although both of these considerations play a part in the derivation of all models, the available models have tended to emphasise either the historical data or economic theory. The difference in emphasis given to data and theoretical considerations partly reflects different views on the reliability of these sources of information. Data-based methods assume that the main features of the financial system can be adequately approximated by directly modelling the data. Theoretical methods assume that the economy is too complex to learn about it by observing it directly and that a substantial part of the historical data may be time specific. As a result, the information contained in historical data may not necessarily be relevant to any other time period. For example, it is assumed that past asset pricing inefficiencies are unlikely to be repeated in future. Economic theories are assumed to be based on more robust considerations.

1.1.3 These methodological differences have resulted in actuarial economic models with different properties and different justifications. Furthermore, the economy has proved to be difficult to model and both types of models have been found to have substantial weaknesses. To illustrate this, we compare the development of Wilkie's model with the development of the jump-equilibrium model. This comparison is exaggerated as these models were not constructed using pure data-based or theory-based approaches. Furthermore, the models are not strictly comparable as they were developed for different purposes. This comparison is made for its pedagogic value.

1.1.4 Wilkie's model was principally developed from historical data using a version of the Box & Jenkins (1970) methodology. Theoretical considerations were taken into account (Geoghegan *et al.* 1992), but the treatment of economic theory was inconsistent (Huber 1997). The efficient markets hypothesis was rejected on empirical grounds (see Ford *et al.*

1980), but the purchasing power parity hypothesis was incorporated in the model despite the empirical evidence (see Wilkie 1995). Nevertheless, Wilkie (1995) primarily defended his model on the basis of its consistency with historical data, which was demonstrated by the results of numerous statistical tests. However, Wilkie's model has been shown to have a number of empirical and theoretical shortcomings (see Kitts 1990, Geoghegan *et al.* 1992, Daykin & Hey 1990, Ludvik 1993, Daykin *et al.* 1994, Smith 1996, and Huber 1997).

1.1.5 In contrast the historical data played a relatively minor role in the development of the jump-equilibrium model, Smith (1996) did not attempt to closely fit the jump-equilibrium model to the data and did not test whether it was consistent with this data. Theoretical considerations were given more importance as the jump-equilibrium model was designed around certain financial economic theories, including the efficient market hypothesis. However, this model also appears to have weaknesses (see Huber 1998). Moreover, the theoretical framework on which the jump-equilibrium model was based has been questioned by some actuaries (see Clarkson & Plymen 1988, Wilkie *et al.* 1993). Much of this criticism has been directed at the unrealistic simplifying assumptions used in financial economic theories. For example the capital asset pricing model (CAPM) unrealistically assumes that agents can borrow and lend at the same riskless interest rate and that agents can easily sell risky assets short (Stiglitz 1989). Clarkson argued that the simplifying assumptions used in financial economics implied that the resulting models were of "no relevance to the financial world in which we actually live" (Wilkie *et al.* 1993: 404). An even more extreme view was taken by Redington (1983) who implied that quantitative methods were frequently not appropriate in economics because of the absence of consistent regularities within the economy.

1.1.6 Rather than relying on unrealistic theories, UK actuaries have often argued that actuarial methods, which rely on mature professional judgement, are more flexible and better suited to determining the economic information required for actuarial applications. This view is reflected in many of the actuarial 'Guidance Notes' (see Institute of Actuaries 1998). However, although judgement is unavoidable in most actuarial applications, it should only be used with considerable caution because it has been found to be potentially subject to logical and statistical errors (see Kahneman *et al.* 1982, Wright & Ayton 1987). This research has found that judgement is most effective when used in conjunction with mathematical models, when experts in probability and the specific subject area under investigation are involved, when a formal coherent structure is used, and when evidential support is provided (Bunn & Wright 1991). In contrast to this, informal judgements can be vulnerable when challenged. This emphasises the attractiveness of a structured approach that employs mathematical models and, hence, the potential advantage of having adequate actuarial economic models.

1.1.7 However, as discussed above, constructing economic models and determining whether they are adequate is fraught with difficulties. As the available models have all been shown to be inaccurate in some respect, can their continued use be justified? Which model development approach is the most appropriate? How should actuaries use economic models in applications? These issues are considered in this paper.

1.2 *Outline*

1.2.1 Section 2 discusses the fundamental difficulties associated with data-based justifications for economic models. Section 3 considers theory-based models and illustrates the importance of having a theoretical framework. This section also briefly reviews the appropriateness of the theoretical framework provided by orthodox financial economics. Although financial economics is shown to have many serious limitations, it is argued that a theory-based approach is the most suitable method for actuarial economic modelling. Section

4 discusses the role of the actuary in the application and development of economic models. It attempts to show how the elusive concept of actuarial judgement can be refined using the ideas from the philosophy of science. Section 5 concludes.

1.2.2 The ideas behind this paper are largely obtained from Blaug (1992), Caldwell (1994), and Hausman (1992). These publications provide more in-depth methodological discussions than can be provided in this paper and the interested reader is encouraged to refer to them.

2. DATA-BASED METHODS

2.1 *Description*

2.1.1 Data-based methods aim to model the behaviour of the financial system directly from the historical data by allowing the probabilistic structure of the data to largely determine the detailed form of the model. Theoretical restrictions are kept to a minimum and generally only used to select the structural form of the mathematical model and the financial data series to be included in the model. The resulting models are then motivated by their ability to describe the historical data. This broad framework for developing models incorporates a number of methodologies including the Box & Jenkins (1970) approach that was partly used by Wilkie (1995), the vector autoregressive (VAR) approach recommended by Sims (1980), and numerical approaches such as neural networks or state-space reconstruction methods (see Weigend & Gershenfeld 1994).

2.1.2 Data-based methods generally assume that the available theories are unproven or inadequate and that the important characteristics of the economy can be directly approximated from the data. Data-based methods avoid the biases implied by inaccurate hypotheses and they capitalise on the finding that statistical time-series models have frequently provided better forecasts than structural macroeconomic models (see Nelson 1972). However, data-based models have significant weaknesses related to the problem of induction and data shortages, which are discussed in this section.

2.2 *The Problem of Induction*

2.2.1 An important problem with of the data-based approach is that the resulting models are entirely dependent on the data sample used and may depict accidental generalisations, or time specific rather than structural features. An illustration of how this may mislead is provided by Jevon's failed attempt, in the 1870s, to prove that business cycles are caused by sunspot cycles because these cycles appeared to have similar lengths (see Morgan 1990). This issue is related to Hume's problem of induction (see Blaug 1992, Caldwell 1994), which broadly states that there is no empirical justification for assuming that the future will be like the past. Past observations cannot form the sole basis of generalisations because they are specific to a historical period and location. As a result, inductive reasoning is unable to provide conclusive proof for a hypothesis or theory.

2.2.2 Inductive evidence does support generalisations, but it is difficult to establish the precise extent to which a generalisation is confirmed by this evidence. This difficulty is illustrated by the paradox of the ravens. The statement 'all ravens are black' is confirmed by every observation of a black raven. However, this statement is also logically equivalent to the statement 'anything that is not black is not a raven', which is confirmed by every observation of a non-black non-raven. Hence, if it is assumed that all statements that are logically equivalent are confirmed by the same observations then a white handkerchief would confirm that 'all ravens are black'.

2.2.3 The problem of induction illustrates the fundamental problem with data-based models. They are virtually entirely dependant on the data sample used and consequently it is not possible to determine whether they represent robust or accidental features of the economy. Data-based methods are only likely to produce reliable models if the system being modelled is sufficiently regular, which does not appear to be the case for the economy over the time horizons required for actuarial economic models.

2.3 *Falsificationism*

2.3.1 The problem of induction is not restricted to data-based methods as theories are also usually developed from inductive evidence. However, according to Karl Popper, it is possible to avoid the problem of induction using the methodology of falsificationism (see Popper 1959, Blaug 1992, Caldwell 1994). Popper exploited the logical asymmetry between the verifiability and falsifiability of universal statements. Although universal statements cannot be established or verified with absolute certainty, they can be refuted or falsified by a single exception. For example, it is not possible to verify the statement 'all ravens are black' because it cannot be guaranteed that a non-black raven will never be found, but it would be falsified by the discovery of a single non-black raven. This illustrates that it is possible to provide valid deductive arguments against universal statements. These insights led Popper to suggest that theories should only be considered to be scientific if they are, at least in principle, falsifiable. Popper argued that scientists should have a critical attitude and should try to falsify their theories using harsh tests rather than try to confirm them. Popper's falsificationism, and the influential adaptation of it suggested by Lakatos (1978) known as the methodology of scientific research programs, has been endorsed by a number of economic methodologists, including Hutchison (1938), Blaug (1992), and Darnell & Evans (1990).

2.3.2 Although falsificationism is not without criticism (see Feyerabend 1988, Hausman 1992, Caldwell 1994), it emphasises the need for scientists to test their theories using tests that have improbable predictions and high prior likelihoods given the theory is true. It also reminds scientists to pay careful attention to their test results and not to easily dismiss negative results. These disciplines suggest another fundamental problem with data-based methods of specifying economic models. It is usually not possible to rigorously test data-based economic models, because economic data is limited and cannot be constructed by experimentation. As a result, data-based methods are usually developed and justified using the same set of data. This practice is inappropriate because it invalidates traditional statistical inference. Thus, Leamer (1983: 38) stated:

> The concepts of unbiasedness, consistency, efficiency, maximum-likelihood estimation, in fact, all the concepts of traditional theory, utterly lose their meaning by the time an applied researcher pulls from the bramble of computer output the one thorn of a model he likes best, the one he chooses to portray as a rose.

2.3.3 Specification searches, or data-mining, result in biased parameter estimates and in overconfident assessments of the model's suitability, known as the optimism principle (Chatfield 1995). The greater the range of the search, the greater the degree of optimism (see Steerneman & Rorijs 1986). This problem is especially prevalent when data-based methods are used because these methods only place limited pragmatic restrictions on the potential range of models that might be considered. Ford *et al.* (1980: 136) claimed that over 400 models were considered before a final equity model was selected. Wilkie (1986: 345) stated: "The particular models have been chosen after consideration of a great variety of alternatives." As models can be designed to satisfy most diagnostic tests, it is meaningless to test a model using the same criteria that were used to design the model (see Hendry 1995). To avoid these problems, a subset of the data could be set aside for diagnostic testing.

However, if the fit of the model over the set aside data is used as a model selection criterion in a specification search, then the tests carried out on this data are no longer independent. Moreover, this practice has been questioned because it results in a loss of efficiency for the fitted parameters (Roeker 1991). This is especially relevant in the case of long term actuarial models where the available data set is relatively small.

2.3.4 Hence, economic models developed using data-based methods are generally not convincing because there is usually insufficient data to enable them to be rigorously tested. Data-based methods merely produce models with high inductive probabilities, so it is difficult to explain why they should 'work' and what events might cause them to fail.

3. THEORY-BASED METHODS

3.1 *Description*

3.1.1 Theoretical models are developed from financial economic theory rather than directly from the historical data. This theory is based on axioms that are similar to those used in neo-classical economics (see Huang & Litzenberger 1988, Bhattacharya & Constantinides 1989). One of these assumptions is that the economy is composed of distinct agents whose only interactions are the voluntary exchange of goods and services. These agents are further assumed to be knowledgeable, self-serving, utility maximisers and to have complete and consistent preferences. Hence, financial economists have attempted to explain financial phenomena in terms of rational agents acting in their own interests.

3.1.2 Financial economic theory provides the foundation for theoretical models. However, this theory is insufficient to completely define an actuarial economic model and a number of auxiliary assumptions are required. These include assumptions about the error distribution functions, the shape of the utility functions, and the precise parameter values. These auxiliary assumptions are chosen using the criteria of mathematical tractability and consistency with the historical data. The resulting models are then usually tested against the historical data and are motivated, to various degrees, both by their consistency with financial economic theory and by their ability to describe the historical data. This framework for developing models incorporates the structural approach used in macroeconomics (see Hall 1995) and the general-to-specific econometric approach (see Hendry 1995). It was used by Smith (1996) in the construction of the jump-equilibrium model and it was partially used by Wilkie (1995) in the development of certain components of his model, such as the exchange rate model.

3.2 *Difficulties with Financial Economic Theory*

3.2.1 Some actuaries have been reluctant to wholly embrace financial economics because its abstract models appear to depend on unrealistic assumptions. However, as Friedman (1953) stressed, unrealistic assumptions are inevitable in models. Economic theories provide internally consistent systems that only abstract the important features of the economy. Hence, they are never completely realistic. Moreover, the main alternatives to developing abstract theories, which involve determining generalisations by experimentation or direct observation, are problematic in finance because of the nature and complexity of the economy and the consequent lack of economic data (see Section 2.3). As a result, actuaries are unlikely to be able to avoid making some unrealistic assumptions. The important issues are whether financial economic theories incorporate the fundamental causal factors, whether they produce reliable predictions that are capable of being refined, and whether their inadequacies can be explained. These issues are considered in this section in relation to

various asset pricing theories, starting with the present value model, which is familiar to actuaries (see LeRoy 1989 for a more comprehensive review of asset pricing theories).

3.2.2 Present value models assume that agents price securities by discounting their expected future cash flows. This assumption implies that the volatility of security prices should be low relative to the volatility of their discounted dividends (LeRoy & Porter 1981). However, empirical tests of this implication have found that it appears to be invalid (LeRoy & Porter 1981, Shiller 1981, Mankiw *et al.* 1985, and Campbell & Shiller 1987). Further problems with present value models include that they imply that investors are risk neutral and that all risky securities have equivalent expected real returns in equilibrium (Singleton 1990). Hence, on the basis of this evidence, present value models do not appear to be empirically adequate. For this reason, other theories have been developed that can be viewed as refinements of present value models.

3.2.3 The CAPM (see Mehta 1992) is a refinement of the present value model that allows for risk aversion. It implies that securities should have persistently lower than average expected returns if they are negatively correlated with the market portfolio. Although the CAPM was supported by early studies (Black *et al.* 1972, Fama & MacBeth 1973), it has been found to deficient in various ways by, amongst others, Gibbons (1982), Fama & French (1992), and Kothari *et al.* (1995). The CAPM's underlying assumptions have also been challenged (see Stiglitz 1989, Clarkson & Plymen 1988).

3.2.4 The fundamental valuation equation (see Constantinides 1989) is a further refinement of asset pricing theories that has had limited empirical success. One weakness is that it appears to be unable to generate a plausible equity risk premium (see Mehra & Prescott 1985, Grossman & Shiller 1981). Although resolutions to these difficulties have been suggested, including that investors have an undiversifiable consumption risk (Scheinkman 1989) and that investor's utilities exhibit habit persistence (Constantinides 1990), a widely accepted, empirically adequate model does not appear to have been discovered.

3.2.5 In addition to the above difficulties, the efficient market hypothesis, on which these asset pricing models are based, has been challenged from a number of perspectives. Direct tests, that attempt to discover profitable trading rules, have suggested possible inefficiencies (see Ford *et al.* 1980, Wilkie 1986, and Dimson 1988). Other empirical difficulties with the efficient market hypothesis include (see LeRoy 1989): that the volume of trade observed in markets appears to be too large given that trading is a negative sum game, that only a small part of ex post equity returns can be explained by fundamental factors, that stock market crashes cannot be fully explained by new information, and that excessive amounts of money seem to be spent on obtaining investment advice. Therefore, although asset pricing theories have been refined and some of their inadequacies can be explained, some serious weaknesses remain (LeRoy 1989). This suggests that actuarial scepticism towards financial economics appears to be justified. However, these conclusions have not been universally accepted because of apparent weaknesses in the above criticisms.

3.2.6 The direct tests of the efficient market hypothesis have been questioned because they assume that agents had complete knowledge. The discovery of a profitable relationship in historical data may merely suggest that investors were not aware of the relationship rather than suggesting that they irrationally forfeited the opportunity to profit from the relationship. If the relationship can be shown to be genuine then investors will exploit it soon after it is discovered so that it will cease to exist in future.

3.2.7 Furthermore, it has been suggested that the volatility test results of the present value model merely reflect the inadequacy of the auxiliary assumptions used (Marsh & Merton 1986). In particular, the volatility tests require an assumption about how investors expect dividends to behave in future, but a robust model of dividend behaviour does not exist.

This illustrates the difficulty with testing individual theories, which is related to the Duhem-Quine thesis (see Blaug 1992, Caldwell 1994, and Hausman 1992). This thesis states that factual statements only have meaning within systems of statements so they can only be tested holistically. In other words, if a test rejects one part of a model, then the whole model is invalidated. The Duhem-Quine thesis is particularly relevant in finance because the auxiliary assumptions on which most tests are based are not well-established background knowledge and can therefore be legitimately challenged. Hence a test may fail because of weak auxiliary assumptions. This illustrates how difficult it is to learn from empirical evidence in finance.

3.2.8 The study of economic phenomena is further complicated by the large number of diverse factors that can potentially influence the economy in complex, irregular ways. As it is usually not possible to marginalise these factors using controlled experiments, economic theories are frequently found to have exceptions. For example, inferior goods are the exception to the general theory that the demand for a good is positively related to income. This implies that these theories represent inexact rather than universal generalisations: they only apply in the absence of other influences. Hence the claim that agents' preferences are transitive assumes that agent's tastes remain constant. However due to the complexity of the economy, it is usually not possible to completely specify the conditions in which economic theories apply exactly. Hence, they are inevitably qualified with vague ceteris paribus clauses and consequently they merely represent statements of tendencies. Black (1986) used the term 'noise' to describe the factors covered by these vague ceteris paribus clauses. Black then defended the efficient market hypothesis by claiming that it is merely a tendency statement. He suggested that security market prices are between half and double their fundamental value because noise makes it difficult for rational investors to precisely identify a security's fundamental value and hence to eliminate 'arbitrage opportunities'.

3.2.9 Noise poses a serious practical problem for finance theory. If finance theory is incapable of producing exact reliable predictions because of a diverse range of factors that cannot be precisely identified then what grounds do financial economists have for remaining committed to their theories? Is noise not just an immunising stratagem that prevents economists from exploring the real behaviour of financial markets? These methodological issues can be addressed using Hausman's (1992) inexact deductive method.

3.3 *The Inexact Deductive Method*

3.3.1 The inexact deductive method is based on the method a priori, which was initially developed by, amongst others, John Stuart Mill in the 1830s. According to Hausman (1992: 124) the method a priori is "the view to which most economists (regardless of what they *say* in methodological discussion) still *apparently* subscribe." This method assumes that the complexity of the economy makes it virtually impossible to learn about it by observing it directly. It asserts that the fundamental causal factors of economic phenomena are relatively well known and can be determined by induction using a combination of empirical observation and introspection. These factors, or basic postulates, include that agents prefer more wealth to less and that agents can and do order their preferences (see Section 3.1). The basic postulates are assumed to represent true descriptions of the predominant causal factors, but due to the complexity of the economy, they merely represent statements of tendencies.

3.3.2 The fundamental economic causal factors are then used to deduce theories concerning the more complicated phenomena of interest. To achieve this, the basic postulates are combined with auxiliary postulates and expository devices. Auxiliary assumptions usually reflect the contemporary economic environment, such as current legislation. Expository devices are approximately realistic assumptions that are employed to make the

problem tractable. As these assumptions are necessarily incomplete and the basic postulates are inexact, theories are assumed to represent hypothetical rather than positive truths.

3.3.3 Hausman (1992) described the resulting theories as models, which he defined as a definition of a concept or type of system. For example, rationality is defined by the model that consists of the assumptions that agents' preferences are complete, continuous, and transitive and that agents maximise their utility. Models do not make empirical claims or provide predictions. They are either trivially true or neither true nor false. Consequently, theoretical economists do not necessarily need to always be committed to the truth of their assumptions and it is inappropriate to assess models empirically. The model of rationality merely defines rationality, it does not state that people behave rationally. The principal aim of models is to provide the means for studying the conceptual, logical, and mathematical implications of sets of assumptions. This guides research activities and enables the development of internally consistent systems. Models have heuristic and pedagogic value in that they provide the concepts that are essential for explaining and comprehending actual phenomena. Without models, knowledge would be restricted to blindly discovering correlations between events using data-based methods. Hence, the development of new concepts, or models, is an important part of financial economics.

3.3.4 However, constructing models is only one part of scientific research. Another vital part is formulating theoretical hypotheses. Theoretical hypotheses are law-like statements that a model is true of some actual system. They state the domain of application of models and thereby create testable empirical predictions. For example, it may be asserted that people behave rationally when making financial decisions. A scientific theory is then defined as the combination of a model and a theoretical hypothesis.

3.3.5 The distinction between theories, theoretical hypotheses, and models is controversial because it is not clear-cut. Theoretical and empirical research are often inextricably interlinked and it may not be helpful to separate them. Nevertheless, this distinction is useful for understanding the theoretical practice of economists, because it is generally not possible to conduct 'closed' economic experiments. Models make systems comprehensible by excluding the complications of reality. In the natural sciences, these 'closed' systems can often be artificially created in laboratory experiments, which makes model building appear to be similar to empirical investigations. Economic models are not able to define an economy precisely, which causes economic model building and empirical investigations to be more distinct. Thus, in economics there is inevitably a partial separation of theoretical and empirical activities.

3.3.6 This definition of a model partially explains why economists do not generally view their theories as universal laws; they are often merely models. It also attempts to deflect superficial criticisms of economic practice. However, economics needs to provide more than just elegant models if it is to be of practical benefit. As a result, researchers need to be either committed to the truth of their assumptions or satisfied that the conclusions would not be materially different if true assumptions were used. Hence, Hausman (1992) rejected Friedman's (1953) claim that the realism of a theory's assumptions are virtually irrelevant to its assessment. Friedman argued that economic theories should be judged by the accuracy of their predictions rather than the realism of their assumptions. However, the distinction between a theory's assumptions and its predictions is ambiguous because it depends on how the theory is formulated. Furthermore, valuable information can be obtained by testing a theory's assumptions or component parts in the same way that a comprehensive mechanic's report is useful when purchasing a second-hand car (Hausman 1992: 166). This information is especially relevant when the theory fails or if the theory is used in situations in which it has

not been comprehensively tested. Hence, Hausman (1992) asserted that scientists should aim to discover generalisations with broad scope rather than models with limited domains.

3.3.7 Hausman (1992) argued that economists cope with the difficulties associated with testing economic theory by using the 'weak-link principle': "When a false conclusion depends on a number of uncertain premises, attribute the mistake to the most uncertain of the premises" (Hausman 1992: 207). This principle invariably implies that the basic postulates will not be questioned. For example, the basic postulate that agents prefer more wealth to less, which underlies the efficient market hypothesis, is generally not challenged as agents are unlikely to knowingly allow others to benefit at their expense from arbitrage opportunities. Moreover, agents have a financial incentive to discover and exploit arbitrage opportunities. This suggests that market inefficiencies are likely to be ephemeral. Hence, Ross (1989: 93) argued that:

> the success of financial asset pricing theories comes from their appeal to the stronger force of arbitrage rather than from a neoclassical demand and supply equilibrium. The most empirically successful theories in finance succeed by emphasising the relative pricing of assets in terms of close substitutes.

In other words, the negative test results of asset pricing theories are due to inadequacies in the neoclassical economic supply and demand models rather than due to difficulties with the assumption of no arbitrage. These arguments suggest that actuarial economic models should not assume that markets are inefficient. If the inefficiency could be shown to be true, then it would be exploited and the model would eventually cease to be valid. Models incorporating inefficiencies are inherently unstable and consequently unsuitable for long term modelling.

3.3.8 Although the weak-link principle is not always appropriate, Hausman (1992) argued that it represents a rational response to a complex problem, rather than a dogmatic methodological rule. However, the claim that the basic postulates should only rarely be disputed is highly controversial because these postulates only represent inexact 'laws' that are qualified with vague ceteris paribus clauses. A reliable universal law cannot even be proven to be absolutely true. However, Hausman (1992) argued that inexact generalisations can be rationally defended if they are law-like, reliable, refinable, and excusable. They must be capable, at least in principle, of being made more reliable, or reliable in a larger domain, in a non-ad hoc manner and the reasons for test failures should be understood. If these conditions are met then Hausman claimed that economists are justified in being committed to the truth of inexact generalisations even though they are apparently falsified. This defence does not justify the assertion that the basic postulates are infallible, it merely claims that it can be rational to have confidence in inexact laws.

3.3.9 The inexact deductive method is also controversial because it is only a partial deductive method, in that it only considers the predominant causal factors. For example, the above-mentioned arbitrage arguments are inexact because they assume that investors have sufficient funds and are willing to take sufficient risks to eliminate inefficiencies (see Pepper 1994). This implies that there is a risk that significant causal factors will be overlooked. It has also been suggested that this method produces theories that are of little practical value because they only describe tendencies rather than accurate predictions. Policy makers are not interested in what would happen 'other things being equal', they need to know what will happen. Nevertheless, the inexact deductive method has been defended on pragmatic grounds as providing the only practical method of learning about a complex system such as the economy.

3.3.10 Another consequence of the problems associated with assessing economic tests is that a theory's pragmatic qualities are likely to be more important than they would otherwise have been. As it is difficult to establish that a particular theory is clearly superior, economists

are likely to prefer theories that are mathematically tractable and provide broadly adequate approximations, such as the models used by Gerrard & Haberman (1996). If a more complicated theory was shown beyond doubt to be better, then it would be used. But, if the alternative only appeared to be marginally better and the evidence supporting this view was ambiguous then it is unlikely that economists would relinquish a theory with substantial pragmatic benefits. Hence, economists have rational empirical and pragmatic grounds for retaining their basic postulates even though the empirical evidence supporting them is equivocal. These grounds could cause economists to become unreasonably dogmatic and to cling to inadequate theories as suggested by falsificationists (Blaug 1992), but this is not a necessary consequence.

3.3.11 Hence, the inexact deductive method asserts that economists start with credible and convenient generalisations that describe relevant causal factors. These generalisations are then used to deduce the required predictions and these predictions are tested. If these predictions are incorrect then economists should: "compare alternative accounts on the basis of explanatory success, empirical progress, and pragmatic usefulness" (Hausman 1992: 222). The deductive method does not assume the basic postulates are infallible, but it allows their initial credibility to be used in assessing test failures. Pragmatic benefits are also given an important role because of the acuteness of the Duhem-Quine problem in economics.

3.4 *The General-to-Specific Approach*

3.4.1 Economic models developed without a theoretical framework have considerable limitations. If they fail, they can only be holistically rejected so that alternatives need to be completely redeveloped. What is more important, little significance can generally be given to positive test results because of the relative paucity of data that is available to test them. A theoretical approach provides the means for interpreting empirical evidence and for constructively guiding research. However, financial economics only suggests broad restrictions to actuarial economic models. It is not sufficient to fully specify an economic model and significant auxiliary assumptions are usually required. The general-to-specific approach provides a sophisticated method of establishing these auxiliary assumptions within a theoretical framework (see Hendry 1995, Gilbert 1986).

3.4.2 The general-to-specific approach starts by establishing an empirically adequate and intentionally overparameterised statistical model using data-based methods. It initially considers general models to limit the need for intensive specification searches. The general model is then comprehensively tested using a range of statistical tests. If the model fails to satisfy any of the tests then the general model is completely respecified and the testing process repeated. These respecifications should not be ad hoc because all the variables, which could possibly be relevant, should have been included in the original general model. If the model satisfies all the tests then it is merely interpreted as an adequate summary of the data. The second stage of the general-to-specific approach aims to simplify the general model and establish an interpretable empirically adequate econometric model. This stage tests prior economic theories using the auxiliary assumptions provided by the initial general model and, if they are corroborated, imposes the relevant theoretical restrictions. Only once the model has been found to be empirically adequate and interpretable is it considered to be a useful addition to our knowledge.

3.4.3 The general-to-specific approach can be interpreted as a pragmatic response to the difficulties associated with economic modelling. It recognises that valid inferences can only be derived from empirically adequate models by initially requiring that an appropriate statistical model be developed. Further, it recognises that general statistical models tend to be inefficient and only provide weak knowledge claims by requiring that models must be

interpreted. Moreover, the general-to-specific approach emphasises that models must be rigorously tested and are fallible.

3.4.4 However, even when the general-to-specific approach is followed, problems are likely to remain. Data limitations inevitably mean that potentially relevant variables need to be excluded from the initial general model and theoretical restrictions are frequently vague. This is problematic as VAR models have been found to be sensitive to the variables chosen and the lag lengths used (see Hafer & Sheenan 1989, Pagan 1987). Moreover, if the initial model is found to be inadequate it may be difficult to identify alternative specifications. Hence, although theoretical approaches, such as the general-to-specific approach, appear to offer the most promising methods for developing actuarial economic models, it is likely to be difficult to establish adequate models. This suggests that no model should be confidently or mechanically used in actuarial applications. As a result, actuarial judgement and sensitivity testing are likely to continue to play an important role in economic modelling.

4. The Role of the Actuary

4.1 *The Application of Economic Models*

4.1.1 If a well-established economic model existed, then actuaries would use it and no further judgement would be required. However, such a model is unlikely to ever be discovered because the economy is an 'open' system with an infinite number of influencing factors, which cannot all be captured in a finite model (Lawson 1994). Further, Rosenberg (1992) argued that the development of economic theories is limited by the nature of agents' expectations and preferences. These variables are fundamental economic variables, but they are not physically measurable because they are intentional: they cannot be independently revealed because actions can only reveal preferences if expectations are known and, conversely, actions can only reveal expectations if preferences are known. Hence, Rosenberg (1992: 129) stated:

> The upshot of the intentional character of the explanatory variables of economic theory is obvious. We cannot expect the theory's predictions and explanations of the choices of individuals to exceed the precision and accuracy of the common-sense explanations and predictions with which we have all been familiar since prehistory.

Not being able to improve on the explanation and prediction of the choices of individuals suggests that economic models are likely to be bound by a similar fate.

4.1.2 Therefore, actuaries are always likely to be dependent on imperfect models and the choice of model will be a matter of professional judgement. This entails understanding the logical basis of potential models and assessing how well potential models are likely to describe the relevant economic variables. For this purpose, the philosophy of science provides some useful insights. It suggests that data-based methods have fundamental weaknesses (see Section 2) and it illustrates the importance of having a consistent theoretical framework (see Section 3). Theoretical concepts provide essential anchors for actuarial judgement as they enable models to be interpreted. This allows actuaries to better understand models and hence to determine the situations in which they are likely to be most effective. Moreover, if theoretical models are used, then it is likely to be easier to communicate the resulting advice to others and, if necessary, to defend this advice by referring to the wider body of research on which the theories are based. To illustrate this, consider how useful present value models would have been if they could not be interpreted. It would not be possible to justify their use by appealing to arbitrage arguments. It would also not be clear that they do not allow for risk aversion and hence are likely to over-value risky assets. An

uninterpreted present value model would merely represent a failed empirical hypothesis of little practical value.

4.1.3 When assessing the strengths and weaknesses of economic models, the philosophy of science also generally emphasises the importance of empirical testing. Empirical validation of models is essential to obtain 'certified knowledge' about a system, such as the economy, whose existence does not depend on theory. In addition to empirical evidence, actuaries may benefit from examining the rhetorical considerations that tend to influence the development of theories, such as the authority of the author (see McCloskey 1986). These considerations may persuade in practice, but they generally should not be used to judge a theory. Hence, Boylan & O'Gorman (1995: 57) stated that: "despite the fragility and fallibility of economic facts and economic testing, empirical evidence is the final arbiter for the science of economics." The importance attributed to empirical testing suggests that although the jump-equilibrium model (Smith 1996) represents a useful theoretical 'model', it should probably be more extensively tested before it is used as a general actuarial economic model.

4.1.4 Therefore, the philosophy of science can be used to refine the concept of actuarial judgement and thereby enable actuaries to defend their assumptions more rigorously. Financial economics provides a potential framework for this defence. Nevertheless, due to the difficulties associated with economic modelling, actuaries are likely to continue using pragmatic models.

4.2 *The Development of Economic Models*

4.2.1 As knowledge is fallible and, in particular, as financial economics has not been overwhelmingly successful, the development of new theories should be encouraged. New theories are essential for advancing knowledge and are valuable when assessing existing theories as they provide benchmarks for comparison (Feyerabend 1988). New economic theories may originate from many diverse sources, including the historical data and existing theoretical frameworks. However, as discussed in previous sections, these new theories should be able to be rigorously tested, which suggests that economic theories developed from purely data-based sources are at a significant disadvantage. Furthermore, this suggests that new discoveries should be scrutinised by the acknowledged experts in the discipline to which they relate.

4.2.2 Hence, although new theories should be welcomed, it is debatable whether the development of new financial economic theories should be the primary concern of actuaries. The actuarial profession has limited resources and there is a danger that the important issues surrounding the application of models (see Section 4.1) may not be given sufficient attention. Notwithstanding its flaws, financial economics is currently the orthodox theoretical framework and it has been extensively researched and tested. Therefore, actuaries have the opportunity to make a significant contribution to the application of existing theories, using methods such as the general-to-specific approach and concepts from the philosophy of science. These existing theories are most likely to be obtained from financial economics, but actuaries should be open to alternative theoretical frameworks to ensure that they continue to provide the 'best possible service and advice'.

5. CONCLUSIONS

5.1.1 Theory-based approaches for developing actuarial economic models, such as that used by Smith (1996), have many advantages. Models developed using these approaches draw their primary support from more fundamental theories, such as no arbitrage arguments,

that have been extensively researched by financial economists. These theories provide a consistent framework that can be used to constructively assess empirical test results and to suggest potential improvements to models. Furthermore, they place the results of applications in an interpretable context so that actuarial judgement can be effectively applied. These characteristics are essential for economic modelling because of the complexity of the economy and the relative shortage of economic data.

5.1.2 However, the theoretical framework provided by financial economics has a number of weaknesses. Financial economic theories tend to be inexact and they are generally not sufficient to fully specify actuarial economic models. This suggests that sophisticated econometric methods, such as the general-to-specific approach, that combine theories with data-based auxiliary assumptions are likely to be optimal. These methods do not solve the problems of economic model building, they merely represent the most pragmatic alternative.

5.1.3 Purely data-based methods of developing economic models are difficult to justify. The resulting models merely represent inductive generalisations and, due to data limitations, they generally cannot be rigorously tested in a variety of conditions. Moreover, if they fail, then they should be holistically rejected to avoid extensive specification searches. This implies that alternatives need to be completely redeveloped.

5.1.4 The difficulties with economic modelling suggest that actuaries will always need to exercise judgement when applying economic models. There appears to be a valuable opportunity for actuaries to undertake additional research into developing robust methods of combining actuarial judgement with theoretical frameworks. The philosophy of science can assist in this research. For example, Hausman (1992) illustrated the importance of having a theoretical framework when assessing models. Further, although empirical evidence is crucial, it needs to be carefully interpreted as a result of the Duhem-Quine thesis. These difficulties associated with testing models suggest that it is likely to be difficult to demonstrate that one economic model is clearly superior to another. This implies that a model's pragmatic qualities will be more important than they would otherwise have been.

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