AN INVESTIGATION INTO THE PHILOSOPHY OF ACTUARIAL SCIENCE

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ABSTRACT

This paper is the result of an investigation into the philosophy of actuarial science. It presents an overview of the empirical and rationalistic tradition of science, discusses recent developments in the methodology of actuarial science and evaluates to what extent actuarial science can be understood within this tradition. The limitations of perceiving actuarial science as an empirical rationalistic science will be discussed and it is argued that this tradition does not provide a complete foundation for actuarial science as a whole because of an inherent ontological deficit, caused by the inability to take into account the role of the practicing actuary. In order to provide a solution for this deficit and to provide a foundation for actuarial practice, the characteristics of practical sciences as originally defined by Aristotle are discussed in the second part of this paper and it is argued that both actuarial practice and actuarial science fit into this framework of the philosophy of practical science and that it provides a justification of actuarial science as a whole. The paper concludes by arguing that the apparent dichotomy between actuarial science and actuarial practice is a false one and calls for a more unifying approach in actuarial science.

KEYWORDS

Actuarial Science, Philosophy, Methodology, Science, Economics, Actuarial, Practical Science, Aristotle

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1 Introduction

Many research actuaries understand their science nowadays as an applied science, which is based on concepts of other sciences and experience of practitioners. It is called applied because it is concerned with the application of knowledge derived from other scientific disciplines such as mathematics, statistics, demography, economics and finance to determine economic and financial consequences of events involving risk and uncertainty. And it is called a science because the general principles of actuarial science are understood to fit into a general framework of modern science. In many countries, there exists an academic education of actuaries. Regularly international scientific meetings are organised and there are many high-level scientific journals available where actuarial questions are analysed and actuarial science is further advanced. Actuarial science has therefore much in common with the modern view of science and can be considered as a part of the economic sciences.

However, there are also differences between actuarial science and other economic sciences. Actuarial science distinguishes itself by an explicit and formal commitment with society. In many countries, the actuarial profession is clearly defined by law and there are actuarial organisations and regulatory authorities that supervise actuarial practice. Actuarial science is not just a science that studies the behaviour of certain objects. Practitioners of actuarial science, actuaries, are individuals who have a formal responsibility comparable to accountants, lawyers and medical practitioners.

It is not easy to see individual actuaries and actuarial practice as a part of actuarial science. Modern science denies the influence of individuals practicing science as much as possible because it is assumed that scientific methods do not result in different conclusions when applied by different individuals. A scientist should be anonymous and comparable to the medieval artist who did not sign his paintings because art was to the greater glory and honour of God and not to the glory of the artist himself. Thus, to perceive actuarial science as a true modern science, actuarial practice is often abandoned from it. Actuarial practice is often degraded to be unscientific because it is concerned with subjective judgements and moral values of practicing actuaries like prudence and conservatism. From a modern scientific point of view, actuarial judgements seem to be the result of a sectarian religion or a secret priesthood where only initiated actuaries are admitted.

At the same time, practitioners of actuarial science argue that changes in practice are almost never the consequence of any research. Research actuaries derive theoretical conclusions, which are irrelevant because the underlying assumptions are arbitrary and are never met in practice. To trust and to use the conclusions of actuarial models, reasonable actuaries are needed who weigh the usefulness of actuarial models, avoid crossing the border to unbridled number mysticism and in the end make sound judgements. Thus, a dichotomy between actuarial science and actuarial practice is created and is preserved by hardboiled scientists and practitioners on both sides and which is further intensified by the influence of other sciences such as econometrics and mathematics.

This article is an investigation into the sense of being of actuarial science, i.e. the philosophy of actuarial science. I believe that neither actuarial scientists nor practitioners of actuarial science from their own side are able to give a complete account of what actuarial science is and, consequently, claim dominion of actuarial science as a whole.

The structure of this article will be as follows. Firstly, I will determine to what extent actuarial science can be seen as a modern science. In order to fit into the general framework of modern science, a discipline has to meet certain scientific criteria. I will derive these criteria from the empirical and rationalistic concept of science and I will check to what extent actuarial science meets these criteria. Then, I will argue that actuarial science cannot solely be understood as a science from the modern scientific perspective because it does not completely meet all scientific criteria and it does not provide a foundation in which we can consider actuarial practice. The second part of this article will begin with a discussion of the Aristotelian concept of practical science. Essential for Aristotle's philosophy is it takes into account the necessary properties and traits of a practitioner of a practical science. For Aristotle, the essential property for someone practicing science was phronēsis, which is nowadays translated as prudence or practical wisdom. The Aristotelian concept of this property is discussed. In the last paragraph, I will fit actuarial science into the Aristotelian scheme of science as a practical and ethical science. In doing so, a philosophy of actuarial science is provided which takes into account the role of practicing actuaries and actuarial practice as a whole by using Aristotle's notion of a practical science.

2 Empirical and rationalistic foundation

Mainstream economics and modern actuarial science understand themselves within the empirical and rationalistic tradition of science. The influence of the empirical and rationalistic tradition in the philosophy of science and science itself can hardly be underestimated. Nowadays, it provides a foundation for many scientific disciplines and has even led to independent trends within sciences. The success of the sciences from which this philosophy was derived led to the conviction that other sciences should also be based on principles derived from this tradition. For example, logical behaviourism in psychology places empirical knowledge at its centre, Durkheim's sociology and Saussure's general theory of linguistics both identify empirical facts from which general theories are derived. Despite this success, strong counter-pressures against this view have emerged.

In order to understand the background of this tradition and to understand the implications for and requirements of empirical sciences, I will start with an overview of the development of empirical rationalistic sciences by starting with Descartes, the Vienna Circle and Karl Popper. Nowadays, Descartes is generally seen as the founder of modern science. With the second the empirical philosophy of sciences and with the third the rationalistic philosophy of science was developed. For this overview, I used de Vries and Leezenberg (2001).

Although the empirical and rationalistic tradition have representatives who disagree on major points and many philosophical debates are concerned with the question

whether models should be based on theory or on data, I will describe this tradition as a one because philosophers of this tradition agree on many crucial philosophical points.

2.1 The empirical and rationalistic tradition of science

Descartes is often seen as the founder of modern science. He devoted his life to the unification of sciences on the basis of a new foundation. In his 'Discours de la methode' from 1637, Descartes noted that "if, among the occupations of men as men, there is any one really excellent and important," it had to be the search after truth. He wanted to achieve the unification of sciences by breaking radically with the at that time dominant medieval Aristotelism, a dominance from which Kepler as well as Galileï did not entirely withdraw. First of all, he designed a method that could be applied to all theoretical sciences. This method was derived from mathematics and led to a methodological unification. His second contribution was the creation of a general worldview where qualities of external object like smell of odours, tastes, colours and sounds were degraded to subjective impressions of the human mind. The physical causes of impressions should merely have mathematical properties. By this drastic solution, Descartes realised an ontological unification of nature. Nature had to be understood in such a way that it could wholly be described by a mathematical method without something being left out. By assuming that nature was the same everywhere a nomological unification of the laws of nature was made. Such a statement is nonlogical because from a merely universal statement derived from empirical observations such as "all A's are B's" one cannot infer the counterfactual "if this were an A it would have to be a B" but from a nomological statement "All A's must be B's" one can. Thus, the Cartesian unification program consists of these three aspects: methodological, ontological and nomological unification. It implied that those elements that could be reduced to impressions of the human mind had nothing to do with what Descartes called science. Based on this evaluation, for example history was regarded as unscientific[1]. The rationalistic tradition was further developed by Baruch Spinoza and Gottfried Wilhelm Leibniz.

Cartesian rationalism first of all led to an evaluation of what was science and what was not. Since the renaissance, an enormous amount of 'knowledge', of theories, statements, interpretations, symbolisms and speculations, was available. Cartesian rationalism led to a hygienic measure, which provided a filter to prevent from being flooded by endless amounts of new knowledge and information. It separated what could be called tried and true and what was untried and therefore untrue. It separated statements based on logic and observations and statements based on authority and tradition. Originally, Cartesian rationalism as a hygienic measure

[1] See for example Part 1 of "Discourse on the method" where Descartes states that "even the most faithful histories, if they do not wholly misrepresent matters, or exaggerate their importance to render the account of them more worthy of perusal, omit, at least, almost always the meanest and least striking of the attendant circumstances; hence it happens that the remainder does not represent the truth, and that such as regulate their conduct by examples drawn from this source, are apt to fall into the extravagances of the knight-errants of romance, and to entertain projects that exceed their powers". He also states "that the memorable deeds of history elevate it [the mind]; and, if read with discretion, aid in forming the judgment" but other than that they were of no use.

provided much relief and led to many new developments. But based on the fundamental assumptions of Descartes, rationalism again developed a world that was too big to describe and new measures had to be developed.

The logical positivists of the Vienna Circle developed their ideas during the interbellum of the First and Second World War. The most prominent figures of this group were Ernst Mach, the founder of the movement, Otto Neurath, who gave the movement its name, Moritz Schlick and Rudolph Carnap. In one way, they were more radical than Descartes was because, unlike Descartes who believed that God created the human soul, they integrated the human mind and spirit in nature and thereby opened the way for a unification of natural and human sciences. However, in another way they were less ambitious than Descartes' science unification project because they understood that the unity of the laws of nature could not be achieved by different parts of science or was at least problematic. As became clear in the nineteenth century, not all natural phenomena could be explained by classical mechanics only. Logical positivists were radically anti-metaphysical and believed that the only way unification could be achieved was by empirical science, i.e. the area of knowledge that is concerned with the description and explanation of sensory perceptions. The idea that all knowledge is derived from sensory perceptions and not by for example inherited ideas, tradition or religious revelation, is called empiricism. The philosophical roots of empiricism can be traced back to John Locke, George Berkeley and David Hume. True science, according to the empiricists, can only be based on empirical facts and the meaning of a theory can only be deduced from empirical truth conditions.

The German Karl Popper criticised (1959) the positivistic view that verification of a theory by empirical facts states something about the truth of a theory. The verification as a demarcation criterion was according to Popper inadequate to distinguish science from pseudo-science. Popper's demarcation criterion, the idea that science is distinguished from pseudo-science by increasing her knowledge by attempts of falsification, answers the question what should be called science and what not. According to Popper, this was a better criterion than the positivistic empirical verification criterion. One can never prove that a theory is true with empirical evidence that confirms the theory. One can only falsify the theory by empirical evidence that contradicts the theory. Theories should not be discovered by induction (generalisation based on a limited number of observations) but by deduction. Statements should be derived in a logical valid way from a theory and these statements should then be empirically checked, possibly resulting in a refutation of the theory. Popper's adjustment of the demarcation criterion of positivistic science and his idea that we do not start with observation but with theory and expectations resulted in what is referred to as the post-positivistic and rationalistic view of science.

Nowadays, many modern scientists understand science from the Cartesian and positivistic view focussing on the unity of sciences. Whether we should be concerned with formulating theories or obtaining empirical data is of course a relevant methodological question but this is a debate, which takes place within what I will call the empirical and rationalistic tradition. Combining these two views is of course a

simplification and looking closer will reveal that the ideas of the philosophers of science do not allow for such a simplification. Even empiricism as a whole of more of less coherent ideas is an abstraction deduced from the interpretations and similarities between ideas of philosophers. To identify empiricism or any other movement or school as distinguished from other schools is therefore nothing more than an induction, which remains in the end unproven. This taken into account, there are important ideas of the empirical and rationalistic tradition on which many philosophers of science and practicing scientists agree. In the following, I will argue that both traditions provide a too limit view to be a foundation for professions with actual involvement in society.

2.2 Counter pressures against the rationalistic and empirical tradition

An enormous amount of criticism and counter pressures have arisen to the rationalistic tradition.

An important assumption of the empirical and rationalistic tradition is the idea that statements can be tested independently and separately. The French physicist and philosopher of science Pierre Duhem (Duhem, 1906) criticised this assumption. The idea that it is possible to test statements independently and separately is often referred to as logical atomism and expresses the form of logical reasoning where compound propositions can be reduced to simple atomary propositions. According to this line of thought, theories can be reduced to statements that can be tested separately and independently by appropriate hypotheses. Duhem showed that there is no such activity as simply observing and reporting of observations. Every phenomenon has to be seen within the context of a theory. Popper also acknowledges this but Duhem differs from Popper by arguing that fundamental hypotheses can never be tested separately. If an experiment leads to results that contradict a hypothesis then it is not said that the hypothesis is wrong. It is also possible that the measurement instruments behave differently from a scientist's expectations, or the method of measurement is wrong or even that the method of calculation is wrong. If data contradicts a hypothesis it is not clear what is wrong. Of course, one can overcome this problem by properly testing the measurement instruments but that does not completely solve the problem of the uncertainty about what went wrong when an experiment contradicts a hypothesis.

Quine translated Duhem's thesis into a stronger thesis about the meaning of empirical content of statements in general (Quine, 1978). Not only it is impossible to test hypotheses separately, it is even impossible to say what an isolated hypothesis is about. Empirical content cannot be localised by reducing statements, only within a theory as a whole it has content. "The beliefs face the tribunal of observation not singly but in a body", Quine noted. This idea has major implications for the philosophy of science.

Duhem and Quine's ideas led to what has become known as the Duhem-Quine thesis. Is appears in weak and strong versions in literature of the philosophy of science. In its weakest form the Duhem-Quine thesis highlights that holistic testing is indispensable to any science. There is no science without the bar of experience.

Logical positivism will not argue this but the way it deals with this is wrong because it gives an erroneous account of testing arising from its logical atomism. A stronger version of the Duhem-Quine thesis states that it is impossible to individually falsify descriptive statements by evidence, how strong the available evidence is, since in another part of the theory always adjustments can be devised to prevent from falsification. The strongest version of the Duhem-Quine thesis is summed up in Quine's famous dictum "any statement can be held true come what may, if we make drastic enough adjustments elsewhere in the system" (Quine, 1951). It is always possible to add an assumption in such a way that the theory as a whole corresponds to the observations.

The Duhem-Quine thesis covers other sorts of criticism because the question can be raised where a theory ends. Some argue that in the end a theory cannot be seen without a set of moral values and that a theory cannot be seen without a paradigm or school of thought and that theories from one paradigm cannot be compared with theories from another paradigm, as Kuhn (Kuhn, 1962) and Lakatos (Lakatos, 1970) argued.

2.3 Economics as an empirical rationalistic science

In the previous paragraphs, the empirical and rationalistic tradition and its counter pressures were discussed. To be called a science, this tradition laid down two requirements. A science should be rational, i.e. it should have a sound theoretical basis and be able to formulate and test theories. And it should be based on empirical facts, which can be used to verify and falsify theories. Just how far a methodology of science should be based on theory or on empirical data is a question leading to many philosophical debates.

Mainstream economics, as it is nowadays known, developed at the end of the nineteenth century. From that time, economics is understood as a part of the empirical and rationalistic tradition and methodologists of economics tried to provide a foundation of their science based on this tradition. This was made possible by two developments.

The first important development was that economics acquired more independence as a value-neutral science of society. Before the end of the nineteenth century, economics was known as political economy and a part of the discipline of the State Administration. Political economy was concerned with the question how the economic system ought and was allowed to work. At the end of the nineteenth century, economics shook off its ‘subjective’ and ethical roots and a value-neutral approach to economics began to emerge. Economists more and more limited the subject and purpose of economics and defended that political economy should be neutral in respect to the political systems and should be value-free. Nassau William Senior, one of the leading figures of the classical school of economics, saw economics as an empirical and positive science. He wrote in 1860 “Whenever he gives a precept, whenever he advises his reader to do anything, or to abstain from doing anything, he wanders from science into art, generally into art of morality, or the art of government”. Another important economist, Carl Menger, wrote in 1889 “It is the

tasks of the science to be concerned solely with fact and not with value". The development of a value-neutral economics coincided with another development in Europe.

The second development, which provided a foundation within the empirical and rationalistic tradition, was neo-classical economics. Neo-classical economics is nowadays the dominant school of economic thought and originated from the development of several economic concepts like marginal utility as a measurable quantity and the theory of economic equilibrium. Almost at the same time around 1870, three economists from Europe formulated a marginal utility theory, William Jevons, Carl Menger and Leon Walras. William Jevons in the United Kingdom argued that value depended entirely on utility and that this utility, or subjective satisfaction, could not be measured directly and can only be measured indirectly by observing human behaviour and preferences. An individual is able to compare utility of successive units of a single good and is also able to compare marginal utilities of several goods. The total utility increases at a diminishing rate. Jevons' concept of utility was influenced by Jeremy Bentham and John Stuart Mill's utilitarianism. Menger also mentioned the concept of diminishing marginal utility, although he did not explicitly name it and did not use mathematics to formalise his ideas. He referred to the decreasing "importance of the satisfaction of needs". Value, according to Menger, is nothing inherent in goods. Value is the importance we attribute to the satisfaction of our needs. Menger also founded the Austrian school of economics. The French Leon Walras created a theoretical model of general equilibrium where he used the concept of marginal utility. These three economists can be seen as the founders of neo-classical economics. Neo-classical economics distinguishes itself from classical economics by a focus on equilibrium, the use of mathematical models and assumptions of rational agents with perfect market knowledge who optimise their behaviour.

Both developments opened the way to an empirical and rationalistic foundation of economics. Many neo-classical economists were inspired by the success of natural sciences and began to develop methodologies of economics based on the empirical and rationalistic tradition and especially on Popper's philosophy. Popper himself did not say much about economics. Most of his ideas were inspired by modern physics and he was particularly interested in relativity theory and quantum mechanics. The application of Popper's philosophy in economics was primarily carried out by economists.

The first economist to issue falsifiability in economics was Terence Hutchison (1938). He criticised the neo-classical assumptions of perfect knowledge and called for the formulation of testable empirical hypothesis. Milton Friedman provided a methodological foundation of neo-classical economics (1953). He adopts many ideas of positivism and also several elements of Popper's philosophy of science. As a reaction on economist's attempts to test the fundamental assumptions of economic theory, he argued that the aim of economics should be to develop theories that provide accurate predictions. The central theme of his philosophy of economy is the use of the hypothetical-deductive method. This method starts by making some assumptions and logically deduces from these assumptions conclusions. Then these

conclusions are empirically checked and inferences are drawn. Then, new improved assumptions can be made and the process starts again. Based on this methodology, Friedman argued that the assumptions underlying a theory do not have to match reality because the assumptions are not directly tested but are indirectly checked by empirical testing the conclusions. From this point of view, the questionable economic assumptions are therefore less important. Thereby, Friedman places empirical testing of economic theories at the heart of economics. Friedman's methodology is often referred to as instrumentalism. According to this line of thought, we should only be concerned with the usefulness of conclusions derived from a theory and thereby seeing theories as merely instruments. The assumptions underlying a theory could be true, but that does not matter with regard to the usefulness. A theory is only justified by its capability to generate true or successful predictions.

There has been some criticism on Friedman's ideas. Lawrence Boland gives an extensive overview of criticism Friedman's essay received (1979). The irrelevance of the question of whether the economic assumptions correspond to reality is not very plausible. Secondly, several scientists have stated that Friedman's advice to empirically test theories is not used in practice. Because the lack of empirical testing, some even argue that mathematical economy is not an empirical science and should therefore be regarded as a discipline within the mathematics.

Modern methodologies of economics based on Popper's philosophy, for example by Blaug (1980), criticised economic theory of not being falsifiable and argue that the Popperian methodology of falsification should be used. However, this idea is criticised by Boland who argues that Popper did not provide a methodology of science but only a requirement for a verificationist's methodological problem. Only if a criterion is used then falsifiability should be preferred above verifiability but thereby does Popper not offer an alternative method of providing a sound foundation of our knowledge. The view, which emphasises the progressive role of falsification, leads to the unjustified conviction that it is an objective method, which will bring us closer to the true theory. Such a mechanical method is an induction, which Popper has consistently criticised. There is no tool, no methodological criterion that can be used to pick the true theories from the false ones. Popper always resisted against using invented criteria of falsifiability but economic methodologists often neglect this view. In other words, the economic methodologist's appropriation of Popper's philosophy is misleading because they read in it a recipe of discovery instead of a recipe of justification.

2.4 Actuarial science as an empirical rationalistic science

There is a growing amount of literature available on actuarial methodology, principles and standards. The general aim of these articles is to fit the actuarial science into the framework of the empirical and rationalistic tradition by identifying the similarities between actuarial science and other modern sciences. In this paragraph, I will discuss recent attempts to formulate actuarial science as an empirical rationalistic science.

Research actuaries and practicing actuaries both have articulated scientific principles and formulated a methodology of actuarial science. For example, Bell et al (1998) describe general scientific principles mainly derived from other sciences. This article was presented by the Casualty Actuarial Society and the Society of Actuaries as a discussion draft, which aims to represent the articulation of the scientific framework that underlies the actuary's work. According to this draft, actuarial science is an applied science because many of the principles are drawn from related fields such as mathematics, statistics, economics and finance. Actuarial science focuses on the financial and economic consequences of events involving risk and uncertainty. In the discussion draft, general actuarial principles are described. These principles are statements of the scientific framework that are grounded in observation and experience. The draft does not discuss normative rules based on the state of art and science of actuarial practice, regulatory constraints and other external conditions. The principles described are related to the statistical, economic and behavioural, financial and actuarial modelling framework and also the principles underlying risk management and financial security systems. Some principles refer explicitly to the actuary's work. The principle of continued validity of actuarial models states for example that the change over time in the degree of accuracy of an initially valid actuarial model also depends upon changes in the actuary's understanding of the environment. Also a degree of actuarial soundness is defined as the probability that a risk management system will be able to pay all obligations as promised. This implicitly assumes that an actuarial model is available from which this probability can be quantified.

Another important attempt to formulate a methodology of actuarial science derived from the methodology of economics and econometrics is done by Pemberton (1999). He presents an extensive overview of the philosophy of science from an empirical and rationalistic perspective and discusses the characteristics of the methodology of actuarial science. Like econometrics, actuarial science has to consider the specific context within which a model is applied and that actuarial science is not mainly concerned with establishing universal actuarial laws. Pemberton describes the actuarial approach as one that uses local knowledge of the situation to be modelled and takes into account the causal influences. From this, actuarial science builds bottom-up models based on these low-level generalisations that have to some degree predictive power. Like in econometrics, stability and regularities are limited and it is necessary to recognise these limitations and to model these irregularities. Therefore, stochastic and scenario modelling are frequently used and actuarial models are continuously adapted to new circumstances by a skilful modeller. Despite the similarities with econometrics, Pemberton argues that there exists a powerful distinctive actuarial method. This method is distinctive because, "by developing predictive models of specific situations based on low-level generalisations, derived from a causal understanding of such realities, it establishes models which are robustly tied to reality".

Huber and Verrall (1998) discuss the value of rationalism for actuarial science by weighing the usefulness of practical actuarial applications of financial theories. They argue that the theoretical framework provided by financial economics has a number

of weaknesses, which are inherited by theory-based models. The assumptions underlying financial economics theories such as agent's expectations, which are inherently unobservable and prone to be irregular, are unrealistic and have a negative impact on the predictions of financial theories. Secondly, they argue that also empirical models, which are directly derived from observed data using statistical techniques, are even more difficult to justify. These models include inductive generalisations and due to data limitations they cannot be subjected to harsh tests. Economic data by which predictions of these models can be tested is only collected by sampling over time rather than by experimentation. Huber and Verrall conclude in their article "that actuaries should not apply their models mechanically. They should be aware of their models' limitations and should be open to alternative theories. Hence they should consider the results produced by all reasonable models, but ultimately they need to be able to rationally defend their assumptions. (…) Their expertise is likely to be better utilised in developing more robust methods of combining actuarial judgement with theoretical models".

Huber and Verrall argue that theoretical models should be combined with actuarial judgements. They thereby implicitly acknowledge that actuarial science can never be abstracted from the specific context within which a theoretical model is applied and thus it cannot be free from moral values of an actuary who applies the model. Regularities and stability of economic behaviour and processes are limited and this has to be recognised when actuarial models are applied. Methodologists in actuarial science acknowledge an indispensable role for the experience based modelling skill.

Contributions to improve the actuarial modelling process were made by Hickman (1997) and Macdonald (1997). In their article, they formalise the process of actuarial modelling and aim to clean this process from subjective judgemental considerations. Other contributions were made by Jewell (1980), who provides an overview of current actuarial models from a Kuhnian perspective and Trowbridge (1989), who describes a number of scientific principles and also actuarial standards derived from practice.

Recent work on the methodology of actuarial science raises the question on the nature of actuarial judgements. Within the concept of empirical rationalistic sciences the influence of the individual practicing science should be diminishable. However, a considerable amount of literature on actuarial methodology emphasises the importance of the influence of an actuary in applying actuarial models. To evaluate these statements, it is necessary to gain more insight into the nature of actuarial judgements.

2.5 Actuarial judgements

As made clear in the previous paragraph, several authors have indicated the necessity of actuarial judgements within traditional actuarial practice. Pemberton argues that actuarial modelling is skill-based and requires expertise and judgements. Secondly, judgements are required for identifying the relevant causes, which influence an output. To take into account the specific context, no universal method can be established and additional expertise and judgements are necessary. Huber and

Verrall arrive at a likewise conclusion when they state that theoretical models should be combined with actuarial judgements.

To positivistic scientists this opposes the concept of scientific objectivity because the result of a scientific method should not be influenced by the individual who applies that method. If actuarial science partially depends on individual judgements, how can one arrive at a sound actuarial methodology? If these judgements are not made explicit then we are not in the position to criticise them and improve upon them. Some argue that it is precisely this subjective judgement, which leads to labelling actuarial science as 'mysticism'. For example, Macdonald (1997) sighs that "actuarial expertise, in this area [incomplete markets] is, unfortunately, a mixture of mysticism and guesswork; such terms as 'best estimate', or 'realistic basis', or 'actuarial judgement' can still be found in the textbooks". If experience and judgements cannot be explicitly modelled then it is of no use to proper scientific actuarial modelling.

What is exactly meant by an actuarial judgement remains vague and it is necessary to define it more properly. Do actuarial judgements arise from subjective impressions of the mind or is there a ground of existence for actuarial judgements within modern actuarial science? To cite Goford in his discussion of Pemberton's article about actuarial judgements: "it is either arrogant nonsense, and we should exorcise it, or it is a real process of logical development and intuitive thinking from experience". In order to provide insight into the concept of actuarial judgement, I will make a distinction between two forms of actuarial judgements.

The term actuarial judgement is often used as a "statistical method" relying on subjective assumptions. The exact process of modelling and the application of models always involve thoughtful considerations and the intricacies of the mind can never be completely made explicit. Often one cannot determine why certain elements are left out of the modelling process or why a small risk of a possible occurrence is neglected. This kind of modelling skill is not a typical actuarial aspect but a general aspect of scientific modelling. Actuarial judgement understood in this way can be the object of scientific research because these judgements can be criticised and tested. It is the object of science to understand and to reconstruct the often implicit models and assumptions as well as possible and to improve upon them. Although there is no general agreement on the question to what extent these judgements can be criticised, one can say that the expressed criticism on actuarial judgements is always concerned with this form of judgement.

One can argue, as Pemberton did, that it is possible to formulate a sound distinctive actuarial methodology and thereby to provide a foundation of actuarial science within the empirical and rationalistic tradition. However, this solves the problems raised only to a limited extent because such a methodology is not distinctive from methodologies used by econometricians and it does not give a complete account of actuarial judgements.

Actuarial judgements also refer to something else. If we boil down the actuary's job to its most crucial element, leave out the modelling process and focus only on the observable aspects of his or her job then one thing is left: the actuarial judgement as the actuary's act of approval of the valuation of insurance liabilities, capital

requirements and tariffs. Only by an actuary's approval the results come into existence and someone can be held responsible for them. This is the only real identifiable actuarial judgement, which can be objectively verified. It is impossible to abolish this form of actuarial judgement without abolishing actuarial science as a whole because ultimately the act of approval is the primary goal of actuarial science. The actuary's act of approval justifies actuarial science. This is acknowledged by many actuarial guidelines, regulations and professional standards, which describe explicitly the requirements of actuarial assessments and reporting processes. The criticism of the actuarial scientific community is concerned with the content of actuarial judgement but not with the act of judgement because there is generally no question on the necessity and relevance of an actuarial judgement as the actuary's act of approval, which is neither mystic in any way nor scientifically unjustified.

Can an actuarial judgement understood as the act of approval be the object of an empirical rationalistic science? It can, but only as an observable phenomenon. One can observe these acts and use this empirical knowledge to derive conclusions about the act. But questions related to actuarial judgements and actuarial conduct in general can never be the object of an empirical rationalistic science because this involves questions of how to take action, which is obviously a matter of ethics. Since Cartesian times, ethical considerations are expelled from science as understood from an empirical and rationalistic tradition.

If it is impossible to abolish this form of judgement and if it cannot be the object of an empirical rationalistic science then the philosophy of this science does not provide a complete philosophy of actuarial science. It is not possible to answer questions related to actuarial conduct within this framework and to derive the essential requirements of someone who is practicing actuarial science. Concluding, the inability to recognise the existence of actuarial acts and the inability to understand its development is an ontological deficit of the empirical and rationalistic tradition. The surrounding reality in which actuarial science operates is larger. Actuarial science is not only about observing phenomena but it is also about interactions with the surrounding world. Actuarial science should also be able to describe this interaction and lay down requirements on actuaries and on actuarial judgements. Therefore, a formal foundation of actuarial practice is needed.

3 Practical foundation

In the previous paragraph, I have argued that actuarial science could not be completely fitted within the framework of an empirical rationalistic science. Actuarial models are not powerful enough to predict data accurately and there is always a need to take into account the specific properties of the context within which models are applied. If there would exist a model, which would accurately predict events then actuarial science itself would not be necessary. To bridge the gap between the results of a model and to make the actual judgement of approval, an actuary is needed. It was also made clear that actuarial science does not aim to discover universal actuarial laws, i.e. to find nomological statements. The purpose of actuarial science is more concerned with the practical application and conclusions of actuarial models and

thus with the ability to represent data, to predict new data and to provide new insights in actuarial policy than in the question whether a model is able to mimic nature accurately. But if the goal of actuarial science is not the Cartesian search after truth, then what is it?

In order to analyse these questions, I will refer back to another philosopher of science, Aristotle. First, I will discuss Aristotle's philosophy of science. His philosophy is based on a distinction between theoretical and practical sciences. Practical sciences are furthermore divided into ethical and technical sciences. The characteristics of and differences between these sciences are discussed. For Aristotle, the essential and necessary property for someone practicing an ethical science was phronēsis, which is often translated to prudence and practical wisdom. In the second paragraph, I will discuss the Aristotelian interpretation of this essential property. Then in the third paragraph, the nature of knowledge in a practical science is described and in the last paragraph, I will show that actuarial science can be understood as a practical and ethical science, which is closely related to the original Greek idea of economics.

Aristotle's philosophy of practical science can be found in Nicomachean Ethics. How we can and should understand the Greek 'in Greek' is an important philological and philosophical question and nowadays there exist different views on how to interpret Aristotle. Aristotle's view as laid down in this article is mainly based by the German hermeneutic and phenomological interpretation; see Heidegger (1961), Arendt (1958) and Taminiaux (1998) for a discussion between Heidegger and Arendt on Aristotle. Recently, there is a growing interest in the Aristotelian idea of economics, see for example Crespo (1998) and Boland (1997), but their views differ on some major points from the German interpretation.

3.1 The concept of practical science

Explaining Aristotle's philosophy of science is not possible without explicit reference to an individual who is practising science. Nowadays, this may sound strange because we are used to divide scientific disciplines according to the objects that are studied and not to the specific interests and traits of a scientist. The modern view of science is that the influence of a scientist should be as small as possible and limited to the anonymous application of proven scientific methods. Science should not be influenced by the moral values of a scientist. Aristotle's concept of science differs from this modern view of science.

For Aristotle, science always starts with the intellectual interest of an individual. His distinction of theoretical and practical sciences is based on the intellectual interest which can differ from one person to another. One can take interest in the surrounding reality which exists independent from him and he can try to find out the fundamental structure of this reality. The sense of this knowledge, theoretical science, is to provide insight into the prevailing principles of nature and cosmos and the individual takes a theoretical and observant role: he is the observer of what exists independent from him. He cannot nor wants to change this reality; he wants to get to know it. The purpose of a theoretical science lies in knowing reality and the existing

unchanging principles, i.e. truth. Theoretical science includes metaphysics, or first philosophy, physics, and mathematics.

Intellectual interest can also be focused on that what is not yet there and comes into existence after human activity. This is the field of acting (praxis), where everything belongs to what derives its existence from human activities: the results of these activities (the society) or by the construction or production of something (a house). The sense of knowledge for this acting, practical science, is not a goal in itself but lies in the realisation of what is being studied: an organised society, a well-considered and safe economy and a good life. Practical sciences thereby advance human activity. Taken as such, practical sciences have a lower status than theoretical sciences: they are not concerned with the unchanging principles but are concerned with the circumstances that are subject to change. Practical ethical sciences Aristotle distinguishes are ethics, economics and politics. These sciences are related to three kinds of communities: the personal, the domestic family and the city or state. Technical sciences or productive sciences, which aim to produce things, are also considered to be practical sciences.

Practical sciences are concerned with questions of what is good for a society, for a safe economy and for an individual. The goal of a practical science lies in the realisation of what is being studied and not in unfolding the unchanging principles of nature. Realisation is not only obtained by critical insight or by forming an opinion but by making explicit decisions and thereby taking concrete action. The questions raised are concerned with conduct and these have no fixity. Instead of theoretical sciences, practical sciences do not aim to indicate the exact truth about the subject being studied. Aristotle writes “Our discussion will be adequate if it has as much clearness as the subject-matter admits of, for precision is not to be sought for alike in all discussions, any more than in all products of the crafts. (…) We must be content, then, in speaking of such subjects and with such premises to indicate the truth roughly and in outline, and in speaking about things which are only for the most part true and with premises of the same kind to reach conclusions that are no better. In the same spirit, therefore, should each type of statement be received; for it is the mark of an educated man to look for precision in each class of things just as far as the nature of the subject admits” (Nicomachean Ethics, I, 3, 1094b 11-26). The subject should be studied to the extent that is necessary to act in a wise way. It is not necessary to find universal laws and methods which create a good society and a safe economy. Practical sciences acknowledge the inexact nature of its conclusions.

Within the practical sciences, Aristotle made a second distinction, namely the ethical sciences based on action (pragma, a thing done) and the technical sciences based on production (product, a thing made). The ethical sciences all involve the exercise of phronēsis (prudence or practical wisdom, a moral virtue). Technical sciences however involve the exercise of technē (art or skill, a technical virtue). This distinction is somewhat problematic because if one defines prudence with ‘the art of living well and rightly’ and if one sees the domestic and political communities as means to achieve the ultimate law of morality then also the ethical sciences are concerned with art. The practical sciences as a whole are therefore sometimes referred to as ‘arts’. But art, in the narrow sense as used by Aristotle, is concerned with the construction and

production of what is external to the mind as intellect or reason. To be able to correctly distinguish what is meant by the exercise of phronēsis and technē, and thus to distinguish the difference between an ethical science and a technical science, the properties of these exercises are further sketched.

The activity that is concerned with production, manufacturing and construction is called poiēsis. What is needed for exercising this activity is called technē, or art, skill and expertise. In this activity, the principle of the product that led to producing it is situated in the maker him or herself. This principle (eidos or archē) is the type or model of the product that is to be produced and it is not located in the product itself. But the goal or purpose (telos) of the activity of production lies in the product itself. The purpose does not lie in the producer because when he is finished and the product is manufactured then the product is independent from him and it can be used for what is originally produced. The purpose therefore lies outside the producer and because the purpose is outside the act of producing, the product is more important than the act. This is distinguished from the activity of acting itself. The activity that is concerned with acting is called praxis. What is needed for exercising this activity is called phronēsis, or prudence and practical wisdom. In this activity, the eidos as well as the telos both lie in the one who acts. The purpose of an act cannot be outside the one who is acting. Therefore, for phronēsis, the praxis is archē and telos at same time.

Essential for the activity of production is that the purpose of this activity is a product that is external from the producer. For the activity of acting, the principle of acting and the purpose of acting both lie in the agent. But this does, however, not mean that ethical sciences are only concerned with the development of a person and that technical sciences are only concerned with the production of things external to persons. The difference is the location of the purpose of an activity. Although the art of medicine is concerned with individual, it should be seen as a technical science because it focuses on improving the health of an individual who is external to a doctor. Of course, one can also argue that the purpose of a political activity, which can have an indirect purpose by influencing others, is in some ways external.

According to Aristotle, economics is an ethical science because it is concerned with action and not with the manufacturing of products. This may seem strange because economics is nowadays often understood as the study of production without any reference to ethical aspects. In ancient and medieval times the term economics was associated with the supervision and management necessary to ensure adequate provisions to a community. Aristotle used the term to distinguish the economy of a household (oikos) from that of a city or state (polis). The management involved was that of a household and economics was equivalent with domestics. Although according to Aristotle, politics was in hierarchy a higher science than economics, he made a formal distinction between the two. He disapproved with Plato's view of an almost dictatorial view of leading a state and the idea that a government has the property of the citizens at its disposal and to distribute it freely as it sees fit.

What should be noticed is that the action to which he refers is the action of someone who is practising the science of economics. It does not refer to general human economic action or production in general and it does not consider the ethical aspects

of the analysed subject[2]. The Nicomachean Ethics was originally written for future legislators and politicians and it focuses on the actions that a legislator and politician should perform in order to create a good society. The praxis is the act or deed of a legislator.

3.2 The concept of prudence

Aristotle identified phronēsis as the essential virtue required to exercise an ethical science. When the Greek works where translated to Latin, phronēsis became prudentia, which became prudence in English as we know it nowadays. However, in the spite of the constant image of the concept, the underlying meaning of it was determined by a specific appropriation of different time eras and cultural environments. In this paragraph, I will analyse the evolution of the meaning of the concept of prudence.

For Aristotle phronēsis, means common sense and practical wisdom. It is the right disposition of a calculating or practical wisdom, and thereby the intellectual property, which makes someone take action according to his of her own insight of what is right and wrong. This virtue should be distinguished from critical insight (sunesis) which judges about these subjects but does not necessarily act accordingly. Who has the virtue of phronēsis is known to be wise (phronimos).

Aristotle's concept of phronēsis differed from Plato's concept because for Plato phronēsis included theoretical knowledge as well as practical knowledge. In Aristotle's work, phronēsis is only related to matters of conduct and thereby looses its privileged and outstanding role. It is the right property of the practical intellect and a special form of knowledge. Knowledge is for Aristotle always related to what is understandable and what is communicative and in that way to what is universal. But prudence is always related to an individual case. A prudent person 'sees' what he has to do in the specific and often complex circumstances of life and is able to relate the concrete cases to what is good and what is not. Prudence thus is a property of the practical intellect by which humans can see that relation and it is knowledge of the specific and the universal at the same time.

It is clear that human action is an indispensable part of Aristotle's philosophy of practical sciences. It is therefore necessary to explain what Aristotle meant by action. Contemplating and taking an observant role is not considered to be acting and playing a part in society. For Aristotle, action always takes place in an open existing network of relations with others. This means that an act takes place in plurality within an environment without borders. Because there are no borders, the results of an act can be unpredictable and because an act cannot be undone, it is always

[2] This is however the way by which some economists read Aristotle. For example, Crespo argues (1998) that economics should be seen as a classical practical science and states that "since human action is ethical and since economic action is human action, therefore political economics has an ethical commitment". He claims that human economic action of producing and acquisition of goods is the kind of action of which Aristotle speaks in Nicomachean Ethics. Crespo's definition of "practical science [which] aims to produce correct statements on human rational actions" focuses on statements and not on actions.

irreversible. In this open network of relations, we interact and communicate with other individuals by using words. The field of acting is therefore closely related to the use of words and action is intrinsically dialectical. There are no general terms to define this action and the words, which we use to communicate, cannot be defined by general definitions. This means that human action can never be free from ambiguity.

A practitioner of an ethical science must take decisions in continuously changing circumstances; he must weigh carefully before he makes a decision and must take into account the context of the whole where action takes place and the cultural and historical environment. Action is always done in plurality. It is impossible to be phronimos, i.e. to be gifted with phronēsis, when one is only concerned with oneself. "It is not possible for the same person to have practical wisdom and be morally weak at the same time" (Nicomachean Ethics, VII, 10, 1152a 7-8).

Around the year 1240, Aristotle's books were rediscovered by the scholastics. In their appropriation of the word prudence, they made a decisive adjustment. The scholastics, of course, saw the practical sciences as a subordinate part of the broader theological and moral concerns and politics, economics and ethics were considered to be a part of the study of moral philosophy. They differed completely from the ancient Greeks in their conception of what was to be understood by a good and useful life and how it should be achieved. In scholastic philosophy the activities to achieve a good society were not seen as necessarily productive for the most perfect happiness in this life. Heaven was to be earned only by penance and mortification and not by the spirited conduct of a man. A good life was the life of an ascetic monk. This differed from the ancient conception of a good life, which saw the realisation of a good society as the main goal. This view of a good and useful life also influenced the interpretation of the word prudence. For example, in Summa Theologiae (1-2.61.5) Thomas Aquinas wrote "thus prudence, by contemplating divine things, counts all worldly things as nothing and directs all thought of the soul to what is divine". Thus, prudence became a virtue for contemplation and not for action and the content of practical sciences changed from achieving a good society and a safe economy to thinking about human behaviour in general. The scholastic appropriation of Aristotle's work resulted in a decisive and principle devaluation of action and speaking.

Until the nineteenth century, the ethical sciences developed within the universities as a part of moral philosophy but for different reasons than Aristotle's. Economics, politics and ethics were considered to be related to ethics because they based on empirical data, which contain moral premises derived from human nature. However, Aristotle originally argued that the ethical sciences were concerned with the action of a practitioner and not with the ethical aspects of the studied subjects. The good life of a scientist remained to be a contemplating one whereby one withdrew oneself from society.

During the Renaissance, which literally means the rebirth (of Greek and Roman times), the interpretation changed back to a virtue to act instead of contemplation. Machiavelli understood prudence as the faculty by which political men make sound determinations about particular circumstances.

It is often stated that prudence is the essential actuary's virtue. The evolution of the meaning of the word shows that prudence cannot be limited to conservatism and cautiousness. It is important to keep in mind that the original Aristotelian idea of prudence is a virtue of the practical intellect which distinguishes itself from the theoretical intellect by an aspect based on the will: the desire to achieve a goal and the decision to act after deliberation influenced by that desire.

3.3 Knowledge in a practical science

A practical science involves praxis, which is normally translated as deed or activity. As already mentioned, the principle and the purpose of a practical science both lie in the act itself. This is a rather vague basic assumption and it is necessary to clarify it.

For this acting, one requires knowledge and, consequently, practical science has a knowing mode in which the relevant knowledge is acquired to act properly. One can ask what knowledge is in a practical science. It certainly is not the theoretical knowledge of the Cartesian philosophy, i.e. objects, method and laws, which are universally applicable. A practical science does not aim at uncovering the prevailing principles of nature and collecting as many facts and laws as possible and, in this sense; it does not aim for theoretical knowledge. Knowledge of a practical science refers to something else.

To know in a practical science is to reconstruct, that is to impose upon the surrounding reality a model accurately enough as that practical needs require. Decisive for knowing in a practical science is the practical need, it is not theoretical representation, which is the attitude from which the knowing mode of a practical science arises and is determined. The attitude of the knowing mode is practical behaviour. At first instance, the surrounding reality is unordered and entangled in confusion. Otherwise, we would presuppose precisely what would originate from the imposition of a model. By imposing a model, specific elements from this surrounding reality are uncovered and at the same time other elements are covered. Here, the term model is used in the general sense and it does not necessarily need to be a mathematical model.

Because only practical sciences are concerned with the realisation of what is begin studied, it is the direct concern of a practical science to withstand to disappearance. If a society is threatened and the practitioners of politics would be unable to withstand, then the goal of politics, which lies in the realisation of a good society, would be at stake and society could fall into anarchy. Thus, the practitioners of a practical science have to act and by their deeds they withstand disappearance and aim for permanence. Only if the practitioners stand fast in the developments and do not submit then the practical science will exist as a practical science. For their own sake, practitioners are propelled toward permanence. A practical science needs on the basis of and for its vitality what is crucial for it as a practical science, namely, that it exists, and that is does not succumb to the torrent of the surrounding reality but erects itself and come to stand in that surrounding reality. Such a standing in the torrent entails a stance against onrush, bringing it somehow to a stand; not in such a way that a practical science comes to a standstill and ceases but in such a way that it

is secured in its stability precisely as a practical science. Praxis is in itself, as occurrence, the securing of stability and because this securing is only possible through making the surrounding reality ordered, it requires models. Practical need means being intend upon forming models that make the securing of stability possible.

In the securing of stability there is a practical need for models, which already looks for what stabilises and what limits. There is always a horizon, which belongs to the essence of a practical science, to the securing of stability in the form of the need for a schema and forming these horizons belongs to the inner essence of a practical science itself.

As already noticed, the aim of economics in early time was associated with the supervision and management necessary to ensure adequate provisions for a community. Thereby, economics was directly concerned with securing of the stability of a community. At another level, politics also aims to secure the stability of a polis.

3.4 Actuarial science as an ethical science

Analogue to the discussion of actuarial science as an empirical rationalistic science, it can be argued that actuarial science is not a theoretical science. The aim is not to provide insight into the prevailing principles of nature and actuaries do not take a theoretical and observant role; they use their knowledge to interact in an environment to achieve certain goals. In this paragraph, I will define actuarial science as a practical and ethical science within the Aristotelian scheme of sciences and I will discuss evidence, which justifies this view.

It has already been shown that Aristotle's distinction between a technical and an ethical science is based on the location of the purpose of an activity. For an ethical science, the purpose lies in the product to be produced and for an ethical science the purpose is located in the act itself. One can argue that premiums, reserves and minimum capital requirements are the actuary's products and that, consequently, actuarial science should be considered to be a technical science. However, that would be a rather limited view of the actuary's work. The actuary is concerned with assuring that the obligations resulting from insurances contracted by an insurance company can be met. Reserves and capital requirements are ways to achieve this goal, but not a goal in itself. Secondly, the product of a technical science can be thrown away if it does not meet the requirements but once an actuary approved the results, the act itself is irreversible. Therefore, the goal of an actuary's act cannot be located in the product and must lie in the act itself.

If actuarial science would be a technical science then it would be sufficient to lay down requirements for actuary's products in order to make sure that the actuary does his job properly. This is however not the case. For example, many guidelines state that in making judgements actuaries should be independent, upright and objectively. These are requirements of practitioners in order improve the quality of their actions and not of their products. Therefore, actuarial science is not a technical science whereby one requires skill to construct actuarial products but actuarial science is an ethical science whereby a practitioner requires prudence, not as a contemplating virtue but as a virtue of practical wisdom.

However, in the often-expressed idea of an ideal situation in which the actuarial modelling process follows a formal scientific method, actuarial models are more and more understood as technical products formulated in such a way that they are located outside the agent. In doing so, the focus changes from acting to producing, thus from an ethical science to a technical science. Perceiving actuarial science as a technical science, the actuary disappears and the same ontological deficit is introduced, as was the case when perceiving actuarial science as an empirical rationalistic science. An actuary who perceives his science as technical forgets that his of her actions are intrinsically dialogical and are aimed to achieve a certain goal. This kind of action can never be limited to providing quantitative information only. This lack of awareness also occurs at a higher level where actuarial science as a whole is unable to provide requirements of actuarial acts.

If actuarial science is not a technical science concerned with the construction of reserves but an ethical science then what is the goal an actuary wants to achieve? With the realisation of what is actuarial science concerned? As it was already argued in the first part of this paper, actuarial science does not aim to find nomological statements. Actuarial models are built for practical applications and actuaries are more concerned with the ability of a model to predict new data and to provide insights than to mimic nature accurately. This coincides with the way knowledge is perceived in practical sciences. Knowledge in a practical science is not a goal in itself but the sense of knowledge lies in the realisation of what is being studied. In actuarial science, knowledge is always used to formulate a model accurately enough as the practical need requires. What is this practical need for which this knowledge is required? Actuaries use their knowledge to perform premium calculations and valuations, asset matching, rating and claim reserving, pension insurance funding and a lot more. All these aspects involve the quantification of some sort of risk and these risks originate from the insurance contracts, which are entered into by an insurance company as a legal entity. Insurance contracts form the horizon of actuarial science and without insurance contracts there would be no actuarial science. The economic and social role of insurance is that individuals can secure themselves for financial stability by means of insurance and nowadays insurance and pensions are one of the pillars of social order. Thus, insurance is directly concerned with ensuring financial stability and actuarial science is the securing of financial stability of society by means of insurances.

This is not an arbitrary way of looking at actuarial science which aims to fit actuarial science within the framework of a practical science.

It has been argued that the growth of insurance companies was not caused by scientific discoveries but mainly by social developments (Daston, 1987). With the emergence of a middle class in the first half of the nineteenth century insurance contracts became the means to take care for a family without the need for public charity. By these developments, society granted insurance companies and actuaries with more responsibilities and there arose a need for actuarial associations and institutes, which aimed to improve the actuarial work. For example, the Institute of Actuaries in Great Britain was established in 1848 and the Faculty of Actuaries, which was founded in 1856, provided the first dedicated actuarial publications. In the

United States the Actuarial Society of America, the forerunner of the Society of Actuaries, was founded in 1880 (Haberman, 1995) and the Dutch Actuarial Association was founded in 1888.

Nowadays the education, appointment and responsibilities of actuaries are formalised by regulations, guidelines and disciplinary rules. Actuaries have the responsibility and the duty to give institutional advice about the sound determination of premiums, reserves and additional capital requirements in such a way that the insurance company or pension fund can meet its future obligations. In many countries, the actuarial profession is clearly defined. In Great Britain the professional status of actuaries is granted by a Royal Charter, in many countries the actuarial profession is defined by law and almost everywhere there are actuarial associations that are concerned with the education and appointment of actuaries.

Daston argues that "only with the emergence of a new rationality that prized security, prudence, foresight, and economic responsibility to one's family could the idea of whole life insurance purportedly grounded upon the certainties of mathematical probability and the regularity of statistics be made attractive to the practitioners of risk". The application of probability theory and statistics for problems in insurance and annuities was originally neglected and was not the driving force behind the growth of insurance companies.

Obviously, there is no definite answer to the question from what development actuarial science did originate because the answer presupposes an idea of what actuarial science is. Actuarial science as an ethical science did not develop from scientific discoveries but from social developments, which led to practical needs for insurance. The recognition of actuarial science as an independent science, which could be distinguished from mathematics, was only possible after the arrival of practitioners of actuarial science who used their knowledge for practical needs. The same holds for scientific discoveries, they are only recognised when their usefulness is manifested.

4 Conclusions

In this article, I have showed that actuarial science can only partially be considered a modern science, i.e. from an empirical and rationalistic tradition. Actuarial and economic data show only too limited stability and regularities and application of methods and statistical inference requires skilful craftsmanship. I concluded that actuarial science does not aim to be a modern science because it is not mainly interested in a methodological, ontological and nomological unification and the empirical and rationalistic tradition does not provide a complete philosophy of science for and a justification of actuarial science. Secondly, this tradition cannot take into account the role of an actuary as someone who makes judgements. Actuarial science considered as an empirical rationalistic science has an ontological deficit in that is unable to recognise the actuary as a part of actuarial science.

In the second part of this article, I have proposed a solution to overcome this ontological deficit by describing the philosophy of practical sciences, which is

grounded in Aristotle's philosophy of science. Prudence was identified as the necessary virtue of a practical ethical science, which was in the Greek sense the intellectual property required to act after deliberation and influenced by the desire to achieve a goal. Then, I discussed the nature of knowledge in a practical science and argued that to know in a practical science means to reconstruct where reconstructing is imposing a model upon the surrounding reality that is accurately enough as that practical needs require. Practical science derives its existence from its securing of stability. After describing the ingredients of practical sciences, it was possible to show that actuarial science could be understood as a practical ethical science. Actuarial science is the securing of financial stability by means of insurances. To do their work actuaries have to be prudent, i.e. they have the desire to achieve this goal and are able to act accordingly after thoughtful deliberation.

The philosophy of practical sciences provides a foundation for actuarial science as a whole. The justification of actuarial science lies in the ability of the securing of financial stability. By this financial stability, actuarial science contributes to society as a whole, which returns respect to actuaries and actuarial science accordingly. Ultimately, the reputation of actuaries and actuarial science is determined by the extend by which actuaries and actuarial science do well for society.

The empirical and rationalistic tradition provides only a limited foundation. Methodologies of actuarial science from this perspective have the tendency to describe actuarial science as it ought to be, i.e. in a normative way. The only true actuarial science is the one, which can be founded upon generally accepted scientific concepts and everything else should be considered as non-scientific. And because all 'ought to be' statements are abandoned[3], practicing actuaries are unable to obtain answers for matters of actuarial conduct and consequently question the value of actuarial research. Secondly, in reducing actuarial science to a technical science, the necessary requirements of an actuary are neglected and not considered to be a relevant question within the scientific domain. In the focus on actuarial models and techniques, there is a risk that actuaries forget their original roots and loose sight over the overarching goal of their actions.

In the view as laid down in this paper, actuarial science should be seen as the whole of actuarial practice and the 'modern' actuarial science as it is nowadays understood. The apparent dichotomy between actuarial science and actuarial practice is a false one, which detracts from the fact that they both have the same ultimate goal; the securing of financial stability by means of insurances. Both sides have to accept the differences and limitations of their domains. Research actuaries have to accept that there are limitations of actuarial science as an empirical rationalistic science and that models and theories can never solely be used as a principle for acting. Practicing actuaries should acknowledge that to make sound judgements in an open, ambiguous and plural surrounding they need an intellectual and scientific core and that it is

[3] There is something inherently strange in this line of reasoning. The statement 'science ought to be without ought to be statements' can never be expressed by a true scientist because he would obviously contradict himself. Thus, who can express this statement?

necessary to continuously review and improve their judgements, which is not possible without proper research.

Actuarial science as an ethical science requires a dialectical approach where debate and challenge are the crucial forms because for a practical science the surrounding reality is dynamic, often implicit and divergent. This requires actuaries with a wide variety of experiences who are prudent in the Aristotelian sense and thus morally strong. In our teaching of actuaries we should focus on a greater intertwining between technical actuarial science and actuarial practice. We should not only teach them actuarial techniques but also make them aware of their tradition.

The foundation of actuarial science as a practical science raises questions on recent developments. The oppressive idea that the value of a thing is a property of the thing itself, which can be objectively measured by observing prices, must be re-evaluated. The value of something is subjective and determined by specific preferences of individuals and consequently the value differs from one to another. A value of something can only be 'fair' if the individual who makes the valuation is fair him- or herself. It also raises questions on the nature of actuarial ethics and how it can be scientifically studied. Is it possible to understand the history of actuarial science as the development of a society of friends who share a common goal to the professional actuarial associations that we have nowadays which give public accountability of their actions?

In his last unfinished book Stephen Jay Gould used the famous poem Strategy by Archilochus ("Fox knows many,//Hedgehog one//Solid trick") to explain the two strategies of the seemingly polar opposites of science and the humanities. Foxes know many things and they survive by their flexibility and skill in reinvention. Hedgehogs know only one thing and they survive by staying on the chosen course with an unswerving persistence. He concludes "I believe that neither pure strategy can work, but that a fruitful union of the seemingly polar opposites can, with goodwill and significant self restrain on both sides, be conjoined into a diverse but common enterprise of unity and power. The way of the hedgehog cannot suffice because the sciences and humanities by the basic logics of their disparate enterprises do different things, each equally essential to human wholeness. We need this wholeness above all, but cannot achieve the goal by shearing off legitimate differences (…). But if we lose sight of the one overarching goal – the hedgehog's insight – underneath the legitimately different concerns and approaches of these great ways, then we are truly defeated and the dogs of war will disembowel our underbellies and win. But the way of the fox cannot prevail either, because too great a flexibility may lead to survival of no enduring value – mere persistence with no moral or intellectual core intact. What triumph can an ultimate chameleon claim if he gains not even the world, but only his basic continuity, at the price of his soul?"

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