Risk based solvency norms and their validity

01 September 2005

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Abstract:

In this article we investigate the resulting empirical situation of accepting a risk based solvency model as a legally valid method to determine minimum required solvency margins. We will apply the positive-normative distinction to probability based statements and with this distinction in mind we will argue that empirical validity cannot be defined as the conformity to the desired situation of a risk-based solvency norm. Instead, it can only be defined as the orientation of action towards that norm. We conclude that the establishment of a solvency norm primarily orients towards the equitableness of risk of all insurance undertakings within the jurisdiction.

Keywords:

Insurance supervision, solvency margin, risk based capital, backtesting, value-at-risk, actuarial methodology

Acknowledgements:

The authors would like to thank Jan Dhaene and Klaas Knot for their useful remarks on earlier versions of this article.

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1 INTRODUCTION

From the early rise of insurance companies in the nineteenth century, there is the question of how insurance undertakings should meet their obligations and, consequently, there is the question of solvency and solvency margins. At the beginning of the nineteenth century, William Morgan of the Equitable Assurance Society was one of the first to realise that to carry forward, a margin of surplus was needed to prevent the policyholder dividend system from breaking down (Mitchell, 1974). In the second half of the nineteenth century, many German scholars, inspired by Gauss' research in astronomy, like Bremiker, Hattendorff and Wittstein tried to formulate requirements for what was around that time called the 'risk' of life insurance companies (Wagner, 1898). Campagne's work after Word War II is a landmark of solvency research for insurance undertakings and by his work the first European solvency requirements for insurance undertakings were put into law (Campagne, 1947 and 1948).

The ongoing research in solvency is currently oriented towards a new approach to solvency of insurance undertakings, which will be codified in the new European Solvency II directives. The new solvency system should provide supervisors with appropriate tools and powers to assess the overall solvency of insurance undertakings based on a risk-oriented approach (European Commission, 2004 and Linder and Ronkainen, 2004). The underlying goal of this new approach is the formulation of an integrated risk-based solvency model that is mathematically and statistically coherent, free from internal contradictions and which is applicable to all types of insurance operations. The formulation of such a solvency model involves, amongst other things, the identification of (coherent) risk measures, methods for measuring risk and risk dependencies from observed losses and methods for risk aggregation into the amount of capital required to absorb potential losses.

An essential element in achieving this goal is that all risks that are included in the solvency model, such as market, credit, insurance and operational risk, are perceived from the same perspective and that they are aggregated through the same mathematical model. The efforts of formulating an integrated risk based solvency model can therefore be summarised as follows: how should a valid solvency model be defined given an integrated approach to a number of risks? An enormous amount of scientific literature has been published that focus on (elements of) this question (see for example Denuit et al., 2005 with over 400 references).

1.1 Goal and relevance

In this paper, we will not go deeply into questions of how valid solvency models should be defined but we will ask some other questions that did not receive as much attention. The goal of this study is to investigate what happens within a group of insurance undertakings if they accept certain solvency norms, codified in national laws and directives, as valid and they direct their own solvency policy towards these norms. Does there exist a relation between the legal solvency norm established by legislators and policymakers and the actual capability of insurance undertakings to meet their obligations? Is it possible to deduce from risk based solvency requirements some sort of guarantee or a policyholder's 'right' and does the existence of a legal solvency norm imply that policyholders in some way have the possibility, guaranteed by the consensually accepted interpretation of that norm, of invoking the aid of a supervisory authority? Related to this are questions concerned with actuarial methodology of risk based solvency models. In what way is the empirical situation created by solvency norms and their enforcement by supervisory authorities open for validation and what does validation mean with respect to risk based solvency models? And, if it is clear how risk based solvency models can be validated, towards what is the improvement of risk based solvency models oriented?

As regulatory solvency requirements are becoming more risk oriented and internal economic capital models are becoming more compulsory, these questions are becoming more relevant. The second Basel Capital Accord will result in more risk sensitive regulatory capital for credit institutions. Similarly, it is expected that the European Solvency II project will also result in more risk sensitive regulatory capital for insurance undertakings. As a result of this, models for regulatory capital become more explicitly risk based than before. In the Netherlands, the new Dutch Pension law states the pension funds require minimum solvency margins that are explicitly based on a risk based solvency model. This development coincides with the increasing use of internal economic capital models of many individual insurance undertakings. By regulatory capital we mean the minimum required or desired capital prescribed by the legislator or the supervisory authority of the jurisdiction in which an insurance undertaking operates. Regulatory capital requirements are primarily formulated in order to safeguard consumer's interests. By internal economic capital we mean the required capital, prescribed at corporate level, for potential losses from distinguished business activities within the insurance undertaking. Regulatory capital and internal economic capital differ on the level of codification of the solvency norm. By a lower level of codification, internal economic capital requirements are less compulsory than regulatory capital.

For this study, an important demarcation of the term 'risk based' is necessary, especially because notions of risk are nowadays used in many different fields of study. Like many words with a long history, the term risk has in everyday language an intrinsic ambiguity and it is appropriated by different scientific environments in various ways. Events, to which risks relate, will not always be defined in the same exact manner and often risks relate to feelings of distress without any objective justification. Not everyone will fear the consequences in the same way and the perception of the significance of a particular risk can be different. To deal with these ambiguities and to use the word risk within a scientific framework, often the given more or less inexact concept of risk (for example a risk definition as the chance of something happening that will have an impact upon objectives) is transformed into an exact one given by explicit rules for its use, which often incorporates it into a well-constructed system of statistical concepts. In this paper, we will limit ourselves to risk as probability. We will explicate risk as the probability that certain adverse events will happen or that a given set of objectives will not be achieved. Often it can be observed that in actuarial and financial literature, the exact concept of risk as probability replaces the inexact concept.

We will investigate models that are based on the assumption that there exists a relationship between the minimum required or desired solvency margin for an insurance undertaking and the capacity of that insurance undertaking to meet its obligations, and where the solvency margin of that insurance undertaking is determined by a prescribed percentage, which is interpreted as the probability to meet future obligations. In other words, the solvency models investigated in this paper determine the required solvency margin such that, for example, with 'a probability of 99.5% or 99.9%' the insurance undertaking does not become insolvent after one year.

To avoid confusion, we will refer to these models as probability based models instead of risk based solvency models. A probability based solvency model in combination with a prescribed percentage results in a norm for the minimum required solvency margin for insurance undertakings. It is generally assumed that the higher the prescribed percentage is, the higher the resulting required solvency margin will be and the more capable the insurance undertaking will be in meeting its obligations. The approach to use a probability based solvency model differs from the so-called factor based solvency models where the required margins are determined by a percentage of an accounting quantity, for example the technical provision.

We will restrict ourselves to the above mentioned solvency models and we will not look to methods to aggregate risks into one measure. We will also not look at other methods to increase the ability to meet future obligations, for example by using additional risk margins in technical provisions.

1.2 Methodology and overview

The current state of solvency research is oriented toward the formulation of a valid risk based solvency model, which should be defined on the basis of mathematical or statistical research and empirical analysis. A large number of policymakers and scientists are inspired by the question of how such a risk based solvency model should be defined and, in doing so, many claim what ought to be the case for a solvency norm on the basis of what currently is the case. In our opinion, this is similar to the situation David Hume noted in 1740. His famous problem, how one can derive an 'ought' from an 'is' (Hume, 1740), has become one of the central questions of philosophical ethics and politics, and Hume is usually assigned the position that such a derivation is impossible. Although, it seems that the solvency research currently employed has nothing to do with ethics and politics and that Hume's problem is not applicable to solvency norms, we will argue that norms, and consequently solvency norms, are normative statements, which express what ought to be the case and that they therefore by definition deal with ethics and politics. We will also argue that there exists a big difference between positive statements (about what is) and normative statements (about what ought to be)[i] and that the jump from a positive statement to a normative statement is certainly not trivial.

In this paper, we will not try to explain the jump and thereby solve Hume's problem; we will not be concerned with the formulation of a solvency model for insurance undertakings by which obligations can be met (an ought statement). Instead, we will ask the question what the resulting empirical situation is, when an ought statement on solvency is expressed (this question therefore investigates an is statement). Our question of what happens in a group of insurance undertakings if they accept certain solvency norms as valid and they direct their own actions towards these norms can more generally be stated as in what way an observed situation will be conformable to the content of a normative statement.

It is our intention to study the concept of solvency from an empirical point of view by looking at available facts only. We intended to write a paper on solvency where the analysis and the conclusions are not open for any form of debate. This investigation is not directed toward some form of opinion or policy advice. Nor do we want to formulate a solvency theory or solvency model describing how solvency requirements should be modelled.

The paper is organised as follows. First, we will analyse statements that in some way are based on probabilities. In the second part, we will apply the results of this analysis to the concept of solvency and we will look at the establishment of the first European solvency requirements. In the third part, we will focus on the validity of probability based solvency norms. This paper ends with a conclusion and discussion.

2 PROBABILITY BASED STATEMENTS

Since the concept of probability entered our vocabulary, it has given rise to numerous discussions on their proper use and there have been many misunderstandings in relation to the interpretation of statements that are based on probabilities. In this paper, it is not our intention to provide a complete overview of the history of probability and statistics (see for a discussion of the development of statistical inference (Stigler, 1986)). We will consider primarily an important distinction, which has played a major role in the philosophy of economics and science in general but which to our knowledge is not explicitly used in relation to probability statements; that is the distinction between positive and normative statements. With this distinction in mind, we will argue that the interpretation of the term probability depends on whether it is used in a positive or a normative statement.

In the first subsection, the distinction between positive and normative statements is explained. The second and third subsection apply this distinction to probability based statements. Then it is explained what the relation is between another well-known distinction of objective and subjective probabilities.

2.1 Positive and normative statements

A positive statement is a descriptive statement on something that exists. A positive statement can be true or false. Truth or falsehood is an agreement or disagreement either to mathematical and logical inquiry, or to real existence or matters of fact. We will not be concerned with the first part, i.e. truth as an agreement to mathematical and logical inquiry. Mathematical and logical questions can be answered independently of empirical data and the ideas upon which such questions depend can be scanned all at once resulting in certainty concerning their relation. Positive statements on real existence are more problematic. The goal of positive statements is to provide a system of generalisations that can be used to make correct predictions.

Normative statements on the other hand are prescriptive statements expressing judgements of what can or should be. They are statements aimed to prevent or produce action of organisations or individuals. A normative statement is always expressed by a subject and we are inclined to say that normative statements are subjective. It is impossible that they can be pronounced either true or false, and can be either contrary or conformable to a positive statement. According to Hume, moral distinctions are never the offspring of positive statements. Positive statements do not imply any action and does not refer to anything laudable or blameable.

This distinction is well known in the philosophy of science (for example, it can be found in Aristotle's philosophy of science which based on the distinction between theoria and praxis). The distinction is also closely related to the demarcation of economics as a logical positivistic science or as a science aimed at policy advice, that is an ethical science. Economists like John Stuart Mill, who mentioned the similar distinction between science and art[ii], Nassau William Senior, Henry Sidgwick, John Neville Keynes[iii] and Lionel Robbins[iv] have used this distinction for several reasons.

2.2 Positive probability statements

Generally, there are two ways in which probabilities can be used in relation to positive statements. First of all, a probability can be interpreted as the empirical relative frequency in the long run and secondly a probability can be used as the degree of reliability of a positive statement in relation to a series of observations. In both cases, probabilities are used in relation to observations and are used to make descriptive statements.

The starting point of a probability as the relative frequency in the long run is a series of observations, that is: events that become manifest or not. It can be the case that within a series of observations, a stable regularity is shown. This regularity shows itself as something, which is not the regularity itself, namely the series of observations and can only be observed via that series.

In practice, we can observe that in a long series of rolls of a carefully crafted symmetrical dice, the fraction of six stabilises itself 'in the neighbourhood' of the number 1/6. From this observation, one is inclined to conclude that the empirical frequency after *n* rolls for *n* converges to infinity in one or another way converges to 1/6. One is furthermore inclined to say that this number is the probability of throwing a six. Analogously, in other experiments one can observe that a long series of carefully executed repetitions the empirical frequency f(A) of event A after *n* experiments converges to a number P(A), and one is inclined to interpret this number as the probability of A.

In this way, a probability is interpreted as the empirical frequency in the long run. The phenomenon that f(A) in the long run stabilises in the 'neighbourhood' of a constant number, is called the empirical law of large numbers. It should be noted that this empirical law has nothing to do with Bernoulli's mathematical law of large numbers. Bernoulli's law is an asymptotical property of a binomial distribution, which has nothing to do with observations. The mathematical law is only a representation of the empirical law under the assumption of equal probabilities. And even under this assumption, Bernoulli's law cannot be seen as an explanation of the observed phenomenon. The assumption of equal probability is an idealisation derived from experience with cannot be proven, Allais (1983). If a series consists of a limited number of observations, or if there is no apparent regularity, then in this interpretation the term probability has no meaning in relation to the series.

A second application of probabilities is to express the degree of reliability of positive statements. In this case, a probability is not interpreted as the relative frequency in the long run, but as the degree of reliability or plausibility that a series of observations originated from a certain probability model. This concept of probability developed from the start of the twentieth century and is nowadays widely used in several areas of science. However, there was no general agreement on an unambiguous definition of reliability. Statisticians like Fisher, Neyman and Pearson formulated different interpretations of this concept, which up to this day lead to many discussions.

For Fisher events were realisations of random variables and he introduced the term statistic for results that are based on one or more observations. To put the concept of reliability into practice, Fisher formulated the so-called *p*-values. He saw these *p*-values and their application in significance testing as the inductive evidence against a certain null hypothesis. A *p*-value gives the 'probability' of the observed data, given the truth of the null hypothesis. A low *p*-value implies strong evidence against the null hypothesis and one is inclined to say that the null hypothesis is 'disproved' or rejected if the sample estimate deviates from the mean of the sampling distribution by more than the specified criterion, the level of significance. According to Fisher, "… It is usual and convenient for experimenters to take 5 per cent, as a level of significance, in the sense that they are prepared to ignore all results which fail to reach this standard" (Fisher, 1966). According to Fisher, a *p*-value represented an 'objective' way for researchers to assess the plausibility of the null hypothesis.

Around the same time that Fisher introduced his *p*-values, Neyman developed his hypothesis testing. He proposed a method to determine the reliability or confidence interval of a parameter of a distribution. In addition to the null hypothesis, also an alternative confidence is defined and this introduces the well-known Type I (incorrect rejection) and Type II (incorrect acceptance) errors. To determine the confidence interval, it is assumed that the parameters of the probability distribution have, with probability one, constant values. In the original formulation of Neyman, a 95% hypothesis interval must not be seen in terms of a conclusion but in term of a process. For someone who calculates 95% confidence intervals the real parameter value will, in the long run, in 95% of the statements made lie within the calculated interval. The percentage is not the probability that a statement is correct, but is the frequency of correct statement by someone who makes confidence intervals. Application of a 95% confidence interval does not mean that we are for 95% certain that the statement is correct.

Fisher's significance testing and Neyman-Pearson hypothesis testing both provide an interpretation of the concept of reliability. However, there are some subtle differences, which imply a different concept of probability (Hubbard and Bayarri (2003)). A hypothesis test differs from a significance test because not only a null hypothesis is considered, but also an alternative hypothesis. This is not the case for Fisher's significance test; the alternative hypothesis of a N(0, l) model is not obvious. At the time these methods were proposed, much discussion arose on which method was better and many doubted whether *p*-values could be interpreted as probabilities. Despite these differences, both methods are used as indications of the plausibility of positive statements. In the merging of the two approaches, it is often taken that Fisher's significance testing implies an alternative hypothesis which is simply the complement of the null hypothesis but this is difficult to formalise. Fisher only had the null hypothesis in mind and wanted to check if the data was compatible with it.

2.3 Normative probability based statements

Normative statements are prescriptive statements and express judgements on what can or should be. In contrast of positive statements, which are about events that did take place in the past, normative statements are almost always about events that can occur in the future. As long as the relevant period to which the normative statement relates did not pass, it cannot be verified whether the judgement of the normative statement was effective, i.e. whether the events that occurred were conformable to the content of the judgement. A normative statement has to be expressed by a subject, which can be an individual, an organisation or the legislative powers within a jurisdiction or a society. We are inclined to say that normative statements are subjective because normative statements cannot be verified at the moment they are expressed and because the statements have to be expressed by a subject. Positive statements on the other hand are said to be objective; they already exist without the precondition that they have to be expressed by a subject. The objective verification of positive statements is in principle open to everyone (Allais, 1983).

There are essential differences in the meaning of probabilities that are used in positive statements and probabilities that are used in normative statements, although the border is easily crossed and the differences are often neglected. To understand the way in which probabilities are used in normative statements, we will investigate several examples of probability based normative statements.

The first example is concerned with coastal engineering design and required safety levels of dikes. On the first of February 1953, the coastlines of the southern North Sea were hit by a severe storm surge. Large parts of the United Kingdom, Belgium and the Netherlands were inundated. In the Netherlands alone, more than 1,800 people drowned and 135,000 ha of land were flooded. Immediately after this disaster, a Delta committee was established to advise the Dutch government on measures to be taken to prevent such a disaster in the future. In their final report, for the first time required safety levels were formulated that were based on a comparison between the economic damage owing to the failure of seawalls and the cost of strengthening the coastal defence works (d'Angremond, 2003). It was established that the sea defences around the most densely populated part of the country should be able to withstand surge levels with ‘a probability of exceedance’ of 10^{-4} per year (what is meant by such a statement will be explained later). In 1958, these required safety levels were accepted by the Dutch parliament and put into law. They were based on the work of a Dutch engineer Wemelsfelder, who already in 1939 indicated that the occurrence of extreme water levels among the Dutch coast followed a logarithmic probability distribution. He also indicated that the crest levels of many dikes, in particular in the Southwest part of the country, were too low. Afterwards, with his model it could be derived that the water level that caused the 1953 disaster had a probability of exceedance of about $3*10^{-3}$ per year.

A second example of the use of probability based normative statements is found in the valuation of derivatives. The problem of the valuation of derivatives belongs to the more general class of economic problems of the valuation of contracts where the outcome for every party depends on the uncertain future occurrence of an event. Many valuation techniques of derivatives are based on (generalisation of) binomial trees. A closer look at these ‘probability’ calculations reveals that they boil down to counting the number of configurations with certain characteristics by applying combinatorial analysis (see the appendix of (Allais, 1983)). Basically, these calculations are calculations of mathematical frequencies in situations where all possible outcomes are simultaneously being realised. Probabilities in binomial tree models and other models derived from them for valuation of derivatives are interpreted as mathematical frequencies (see for example the way in which probabilities are used in (Cox et al., 1979)).

A third example also belongs to the general class mentioned above and deals with the valuation of future insurance liabilities and the use of simulation techniques. Certain regulatory guidelines, for example the guidelines of the Australian prudential supervisor APRA, state that technical provisions are sufficient if they are determined at such a level that with a confidence interval of 75% the future payment obligations can be done. The analytical structure of these valuation models is often too complex to derive closed form expressions for output variables and therefore often simulation techniques are used. Input probability distributions are defined that are assumed to be representative for possible future situations. The probability distributions used represent the mathematical frequency of the input variable. Normally, a large number of possible outcomes is produced based on the mathematical frequency distributions of input variables. The outcome of a desired output variable is of course again a mathematical frequency distribution. Although many pseudo random number generators that are presently being used in simulation software satisfy generally accepted criteria for ‘randomness’, the process of producing possible outcomes is completely deterministic; the computer algorithms that are used cannot produce pure random numbers, if such procedures would exist at all. Every set of simulated outcomes can in principle always be reproduced. Simulations of future outcomes are, like in the example of the valuation of derivatives, based on the simultaneous realisation of all possible outcomes.

What can be learned from these examples? Probabilities in normative statements are often interpreted as mathematical frequencies. In doing so, it is assumed that all future events will manifest simultaneously according to a certain mathematical frequency distribution. Based on these mathematical frequency distributions, normative statements express some form of judgement: how high the coastal defences should be, what the price of a financial derivative should be and what amount of technical provision should be reserved for future insurance obligations.

To assert a probability based normative statement, two important assumptions are necessary. The first assumption acknowledges the reasonableness of the representation of the empirical frequency distribution that was observed by the mathematical frequency distribution that is used for the future. Probabilities are interpreted in these examples of normative statements as mathematical frequencies and not as empirical frequencies. By doing so, it is assumed that all future events will manifest simultaneously according to a certain mathematical frequency distribution. The second assumption acknowledges the axiom of invariance of economic and demographic regularities and the laws of physics, according to which the observed regularities will be repeated in the future. Both assumptions cannot be tested at the moment the statement is expressed. With statistical methods, mental experiments, interpretations and extrapolations, it is possible to make it more or less plausible that these assumptions are true or false, but they can never be proven to be true or false.

Therefore, probability based normative statements always express subjective judgements. This subjectivity is unavoidable but that does not mean that normative statements are arbitrary or unreliable and that their subjectivism should be avoided as much as possible. In a normative statement, the subject shows itself, and often the subject cannot be separated from the expressed statement. Often, we have more confidence in a normative statement if that statement is expressed by an independent organisation or an individual that we trust. And this confidence and trust diminishes if evidence manifests, which contradicts the image evoked by the statements expressed by the subject. Therefore, if we test a normative statement we also value the reliability of the organisation or the individual that expressed the statement. For example, the statement of a weather forecaster that 'in a certain area it will rain tomorrow with 80% probability' can never be verified or falsified. By his statement he evokes the idea that it is more probable that it rains than that it does not rain and that one should take an umbrella when going out. The sole event that it will rain with 80% probability cannot be observed. It will rain or it won't rain. But if a weather forecaster makes this or a similar statement every day for a whole week and if every day the less 'probable' event is observed then we will value the weather forecaster as a poor forecaster of rain and we will not trust his forecasts anymore.

A normative statement can be ambiguous in the sense that the exact way to explicate the statement is unknown and open for discussion, but normative statements are never uncertain. Although one can argue about the content of the normative statement, one can never argue about the fact that the normative statement is expressed, especially if the normative statement is put into law. For positive statements the exact opposite holds. Positive statements can be uncertain, and probabilities are used to express the level of certainty of the statement, but they can never be ambiguous because otherwise they cannot be objectively verified or falsified.

Therefore, the concept of probability as mathematical frequencies is completely different from the concept of probability as an empirical relative frequency in long run or as some form of reliability. What is meant by probability depends on whether the term is used in a positive statement or a normative statement.

2.4 Objective and subjective probabilities

Another well-known distinction that is often used in relation to probability theory and that should be mentioned here is the distinction between subjective and objective probabilities. This distinction, as it is generally understood, is not identical to the distinction described above. It is important not to confuse them.

A subjective or personal probability refers to a degree of belief of an individual about the correctness of a statement. The term subjective in this case implies that this construct is based on a belief specific to a certain subject, namely the individual. If that individual does not have enough information, then he will be uncertain about the correctness and he will reflect that uncertainty in his subjective probability about the proposition. An objective probability on the other hand is assumed to exist outside the mind of subjects and is based on formal probability theory and statistical inference. An objective probability refers to the ‘true’ degree of belief about the correctness, i.e. the reliability, of a statement. Because we used the term subjective also in relation to normative statement, it would apparently be correct to relate the normative statements to subjective statement and the positive statements to objective statements.

Normative statements and subjective probability statements refer to different kinds of subjectivity. What is subjective in a normative statement is that the statement is a judgement about what can or should be which is expressed by a subject, i.e. by an individual, an organisation or the legislative powers of a society. The expression of a judgement is itself not uncertain and it can be empirically verified by others. But subjective probabilities are not about expressing a statement but about believing a statement. A subjective probability statement refers to the degree of belief of an individual on whether something exists or not or whether something is true or false. Subjective probability statements refer to how probable positive statements are from the viewpoint of an individual. They are not about what can or should be and do not have the moral implications that normative statements have.

A formal approach that includes personal beliefs, insights, intuition of and information and knowledge held by the scientist prior to an experiment is Bayesian statistical analysis (see Press and Tanur (2001)). The Bayesian approach is a way of making inferences that builds on earlier understanding of a phenomenon and that formally combines that earlier understanding with currently measured data in a way that updates the scientific belief (subjective probability) of the scientist. The earlier understanding is called the prior belief, i.e. the subjective knowledge in the form of a belief or understanding held prior to observing the current set of data. The new belief that results from updating the prior belief by combining it with the experimental data is called the posterior belief, i.e. the belief held after having taken the current data and having examined those data in light of how well they conform to preconceived notions. This inferential updating process is called Bayesian inference. Bayesian statistical analysis is an approach that uses subjective probabilities for positive statements based on empirical verifiable phenomena. The probabilities used in positive probability statements can either be objective or subjective.

Questions of whether certain phenomena occur by pure chances or whether their occurrence is entirely deterministic in nature, whether objective probabilities exist at all and whether these probabilities are open for objective measurements without any theoretical considerations are questions that are essentially metaphysical; one can form an opinion on them, but one cannot define a consistent and definite answer to these questions, not in the sense that this answer is in accordance with observations and not in the sense that there is some form of general agreement on or acceptance of that answer. In practical reasoning these questions are of no use.

3 THE CONCEPT OF SOLVENCY

For insurance undertakings solvency is one of the central issues and one of the primary management responsibilities. Macro-economic developments, failures in investment, miscalculations in underwriting operations, in amount of claims that fluctuate considerably and in biometric rates, malfunctioning risk and actuarial functions can contribute to severe negative variations in results.

In general, the solvency of an insurance company in relation to some uncertain future obligations cannot be guaranteed with certainty. Because the ability to meet obligations depends on the internal and external circumstances of an insurance undertaking, the solvency policy that an insurance company implements, must also depend on these specific circumstances. Thus, there are no generally applicable definitions to determine with certainty the required amount of solvency margins.

Because of that, often distinctions are made between different kinds of solvency by making clear in what circumstances obligations can be met: static solvency which is related to the liabilities that have to be paid on an immediate liquidation of an insurance company (break-up, wind-up or run-off approach) and dynamic solvency which is related to the liabilities that have to be paid as they mature (going-concern approach) (Campagne, 1961). In the first approach one would only consider written business, in the second approach one could also take into account future new business. Some definitions of solvency take this into account and state that an "… insurance company is solvent if it is able to fulfil its obligations under all contracts under all reasonably foreseeable circumstances" (IAIS, 2002) and thus limiting the definition of solvency to circumstances which are reasonable foreseeable. Sometimes, a horizon is adopted and a certain degree of probability of becoming insolvent is considered.

3.1 Available and required solvency margins

It is generally accepted that holding a level of solvency is related to the capacity of an insurance undertaking fund to meet its financial obligations. Originally, the concept of solvency is related to the capacity to meet obligations. The term solvency is related to the Latin verb 'solvere', which means to loosen, to dissolve and to pay. Being solvent is the quality of state to meet financial obligations. In the financial literature, the term solvency is often used in this sense. Insurance undertakings are often concerned with long-term obligations. A statement on solvency of them is based on future events of which the outcomes are inherently unknown. Whether an insurance company is solvent in relation to future obligations is not known and such a statement cannot be empirically verified before all obligations are met. In practice, it will almost never be observed that an insurance company will run off its obligations completely on its own and it is almost never possible to verify whether the obligations are truly met. However, if an insurance company is not able to meet its obligations and is insolvent, then this will be clear to everyone.

From this goal of solvency related indicators are derived, e.g. available solvency margin as the difference between assets and liabilities, i.e. the free capital, (Pentikäinen, 1982) and the solvency ratio as the ratio between the available and the required solvency for insurance undertakings and the level of funding for pension funds. Also the level of prudence of the technical provision is assumed to be a solvency related indicator. It is generally assumed that these indicators are reliable signs of the solvency of an insurance company. The higher the available solvency margin is, the higher the capacity to meet the obligations will be. However, these indicators do not coincide with the concept of solvency as defined above. It is important to recognise that the indicators are nothing more than indicators.

A positive statement on solvency is a statement that, in principal, in the end can be verified. Distinguished from that are normative statements, expressed by an individual, an organisation or a society, of what should be in relation to solvency. In this case, solvency is seen in relation to others and is related to future situations and the general case. A normative statement is therefore not grounded in the observation of meeting obligations but it is grounded in unanimity; without unanimity of the legislative powers, there would be no normative statement or norm on solvency. The relevant question in this case is what minimum required solvency norm is just with respect to all insurance undertakings within the jurisdiction. What is just is not only determined by the question what minimum solvency margins are necessary to meet obligations but also by what is possible within a given political environment and what makes sense and what fits within an assumed economic reality. A solvency norm fails in relation to others if it becomes clear that the norm does not provide a good representation of the equilibrium of powers in which the norms was originally established.

3.2 Origin and evolution of EU capital requirements for insurance undertakings

It is assumed that the origin of the EU capital requirements for insurance undertakings goes back to research of the Dutch Cornelis Campagne, who published an article on extra reserves, i.e. solvency margins in 1948[v]. In this article, he described a method to express the required solvency margin in terms of a percentage of the technical provision, which was based on a so-called safety percentage. Basically, the method that Campagne described corresponds to the Value-at-Risk approach (formal descriptions of the VaR approach can be found in many textbook on statistics and probability theory, for example Denuit et al., 2005). What was the background of Campagne's concept of safety percentages?

Campagne observed that broadly speaking every insurance company had built up a certain extra reserve in the course of years, which is greater in proportion to the technical provision according as one was able or willing to reserve large amounts. The available solvency margin could be expressed as a percentage of the technical provision and the senior management of insurance undertaking took a point of view, which differed only in quantity. From this observation, Campagne concluded that "… on the whole the leading thought was that a careful management is imperative and that consolidation of the financial position was no superfluous luxury". Furthermore, Campagne argued that one has hardly any well-founded opinions about the safety-margins one practices.

The method proposed in the article enables to give a rough calculation as to what degree one is safe at a given technical provision and solvency margin, or "… in what safety percentage do we find ourselves approximately, if the extra reserve form e.g. 5 or 10% of the mathematical reserve". From this, he formulated the starting point for a normative statement on the required solvency margin by asking "… how great has the extra reserve to be, so that with a probability smaller than 1/100 resp. 1/1000 this can be expected to be insufficient for the financing of investment losses and deviations of foundations, in which case furthermore distinction have to be made between cases in which the stabilization reserve has to be sufficient for one year or for more years".

Campagne acknowledged that his method was only an initial approximation and that due to the lack of data the question could not be answered exactly. His analysis was based on the annual reports of a group of ten of the largest Dutch life insurance undertakings (by the standard of the amount of premium reserve) drawn up for each separate financial year the profit and loss figures for the financial years 1926 up to and including 1945. This assumed some speculative elements concerning the external circumstances and the political environment, but "… the result is that the application of frequency-figures from the past to characterize probability figures for the future is in fact impossible". Despite this remark, the figures were used normatively for the future.

Given the annual reports, Campagne came to the following conclusions. With a probability of 99% an extra reserve of 6% of the technical provision appears to be adequate and independent of the number of years. With a probability of 99.9% this percentage becomes 9, with a probability of 95% it is about 4. Campagne argued that this conclusion indicates the necessity of the solvency margin. However, he did not relate his safety percentage explicitly to the probability to meet future obligations.

Campagne's work gave in a sense a justification of the required solvency margins for insurance undertakings and this was not unnoticed by others. His approach became leading for the method to determine minimum required solvency margins for life and non-life insurance in the European Directives. When after World War II the European economic integration took shape, there was a growing demand to make arrangements on a European level for the minimum required solvency margins for insurance undertakings. The establishment of the European Economic Community (EEC) in 1957 also gave an impulse to the cooperation of the supervising authorities. The Conference of EEC Insurance Supervising Authorities[vi] began to discuss the steps toward a single European insurance market. At a request of the Organisation of European Economic Co-operation (OEEC) Insurance Committee[vii], that facilitated discussion between the insurance industry and supervising authorities, Campagne presented in 1957 a report on solvency. He argued that for reviewing the financial position of insurance undertakings theoretical assumptions had to be made. He emphasised that his approach did not give any information on the real solvency position of insurance undertakings but that it was primarily to be used as an early warning system. The OEEC Insurance Committee established a working group, chaired by Campagne, which presented in 1963 the results of the approach taken in Campagne's article of 1948, based on annual reports of European insurance undertakings. For the minimum required solvency margin for life insurance undertakings as a percentage of the technical provision, the working group proposed a safety percentage of 95%, which resulted in a required solvency margin of 4% of the technical provision.

Campagne's proposals were at that time almost completely rejected by other experts (see for example (Ammeter, 1966)). The statistical and theoretical assumptions were taken into doubt and there was criticism against the practical implications of implementation of the criteria proposed. A number of insurance undertakings would not be able to meet the proposed required solvency margins. Also the determination of required solvency margin as a percentage of the technical provision was criticised. Some observed that the required solvency margin should be based on the total capital at risk. Furthermore, it was unclear how the technical provision was to be determined. This could lead to unwanted results because, for example, insurance undertakings that determined their technical provision more prudent than others should also hold a higher amount of solvency margins. It was also illogical that new insurance undertakings were not required to hold a significant amount of solvency. Instead of formulating a norm for the required solvency, general requirements should be determined based on what were feasible within every jurisdiction and which could consequently be different for each jurisdiction. An extra margin would not be necessary. This was for example proposed in (Skerman, 1966).

Much criticism boiled down to the argument that the norm that Campagne proposed for the minimum required solvency margin was not a proper indicator for the capacity of insurance undertakings to meet their obligations. Despite this criticism, Campagne's proposals were codified in the First European Directive, which was accepted by the European Economic Community on the fifth of March 1979. This directive marked the first steps toward the establishment of a single European market in insurance. The minimum required solvency margins were adopted without changes in the Second (1990) and Third Directive (1992).

Nowadays, the required solvency margins for life insurance undertakings are expressed as a percentage of the technical provision. However, the original justification of that percentage lies in the Value-at-Risk approach proposed by Campagne. At the time the approach was accepted, the leading thought was that direct application of the Value-at-Risk approach would lead to required solvency margin that would differ for each insurance company and that these differences were unwanted. De Wit and Kastelijn in 1980 argued that, when it was possible to translate the theoretical model into practical application, "… the results would upset relations between competitors, so that it seem natural to make the required solvency margin the same for all companies".

4 PROBABILITY BASED SOLVENCY NORMS AND THEIR VALIDITY

In the previous section, we argued that probability based normative statements are judgements of an individual, organisation or the legislative powers of a society that, at the moment they are expressed, cannot be verified or falsified. Accordingly, legal solvency norms on the minimum required solvency margin are normative statements (national laws or European directives) expressed by the legislative powers and analogously, they cannot be verified or falsified either. We would be inclined to conclude that there is no relation between probability based solvency norms and their empirical validity. However, the formulation of a law or directive on solvency does not only involve formulating statements on solvency requirements. It also involves giving the right amount of powers to legal supervising authorities to enforce compliance to solvency requirements. A solvency norm can only be considered a norm if there is a chance that a supervisory authority will enforce, in a given situation, compliance to that norm. Otherwise, it would fail to the definition of a norm. By that legal enforcement a relation is obtained between the solvency norm and its empirical validity. But what does that empirical validity mean? In this section, the empirical validity of probability based solvency norms is investigated.

First of all, we will distinguish legal validity from empirical validity. A norm is valid within a jurisdiction, from a legal point of view, if the legislative powers of that jurisdiction accept the norm. We will call this kind legal or normative validity; it means to declare or to make legally valid. From this point of view, there is no causal relationship between the validity of a norm in the legal sense and any empirical process. Relevant questions are what the content of the normative description of solvency norm should be, whether the norm is applicable in practical situations and whether a solvency norm as correctly interpreted in the legal sense can be applied to a given situation. However, legal validity is not the kind of validity we are interested in.

Empirical validation means to establish the soundness of statements. Empirical validation is often interpreted as the verification, the confirmation between a statement and observations, or the falsification, a misrepresentation of statements and observations.

4.1 Validity as conformity to the desired situation

A first intuitive approach to define the empirical validity of a solvency norm would be the realisation of the desired situation of the norm. Suppose we would take a probability based solvency norm to determine the minimum required solvency margin. We would be inclined to say that the desired situation of a probability based solvency norm is that the available solvency margin of each insurance undertaking is such that with a probability smaller than a certain percentage, for example 0.5% or 0.1%, it is sufficient for one year (or more years) for the financing of investment losses, deviation of assumptions and other negative variations of outcomes. Note that this situation is a positive statement because it is based on the available solvency margin. Often the suggestion is made that holding a probability based solvency margin implies the realisation of some desired situation, for example by arguing that a $(1 - p)$ solvency level corresponds to, on average, $1 / p$ occurrences of insolvent situations. However, whether such a situation is the case depends on a large number of internal and external factors, such as the solvency models used, the success of the solvency policy of the insurance undertaking and external economical, demographical and environmental variables.

What are the methods to determine the empirical validity of the positive statement stated above? In the previous section, we observed that probability in positive statement could be used as either the empirical relative frequency in the long run or as some form of reliability.

The first case, where probability is interpreted as the empirical frequency in the long run, is in practice only to a limited extent open for empirical validation. If the solvency norm would be a one-year norm then an empirical validation requires a large number of observed years before one could make a reliable distinction between for example 99.5% and 99.9%. The empirical frequency does not provide a reliable basis for current solvency policy and actions.

The second case, where the probability is interpreted as some form of reliability (based on significance tests or confidence intervals) of the positive statement, provides a level of confidence of the truth of the statement. Empirical validation of VaR-models is also known as backtesting and a number of tests have been proposed. A widely used test is the basic frequency-of-exceedance test, which is also known as the binomial or Kupiec test (Kupiec, 1995). The idea is to test whether the observed frequency of losses exceeds the corresponding values of VaR-model (or frequency of tail losses) is consistent with the frequency of exceedances predicted by the model. A null hypothesis is used which states that the model is adequate, i.e. consistent with the data, is the number of exceedances follows a binomial distribution with parameters n and p where n is the number of observations (the number of observed years) and p, the predicted frequency of exceedance, is equal to one minus the VaR-confidence level (see for a more extensive treatment Dowd (2002)). The basic frequency-of-exceedances test has a simple intuition, is easy to apply and does not require a great deal of information. This test calculates the 'probability' that the data is generated by a binomial probability model; it therefore produces inductive evidence against the null hypothesis. This is conceptually analogous to Fisher's p-values. However, it should be noted that Fisher's significance test and his p-values differ from Neyman's hypothesis testing procedure in that there is no alternative hypothesis proposed alongside the null hypothesis and that type I and type II errors are not applicable. A complete alternative hypothesis cannot be stated in the basic frequency-of-exceedances, although this is done in practice. This test is inductive evidence against the null hypothesis and it should be seen as a measure of reliability. A more advanced frequency-based approach that does take into account the patterns of exceedance is the conditional backtesting procedure suggested by in (Christoffersen, 1998). Backtesting procedures that are more explicitly based on Neyman's confidence intervals transform the observed data the same metric given by the forecasted cumulative density and then test the transformed data. Under the null hypothesis that the model is adequate, the Rosenblatt transformations of the data are distributed as a standard uniform distribution. The Rosenblatt-Berkowitz transformation uses a second transformation to make the data standard normal under the null hypothesis (Berkowitz, 2001). These tests provide reliability of a positive statement based on a VaR-model.

However, a disadvantage of the proposed backtesting procedures is that they are unreliable except when a very large number of observations is available. And this large number of observations is not available for one-year solvency requirements. Furthermore, it is an open question whether the percentage of exceedances will stabilise around a constant number. This phenomenon only occurs in a long series of carefully executed repetitions within a situation of invariant economic regularities. It is at least to be doubted whether improved methods of backtesting will overcome these difficulties.

As well as the empirical frequency, these tests only to a limited extent provide reliable basis for current policy and action. It is impossible to objectively verify whether in case of solvency ratio of less than 100%, this situation was 'caused' by the application of an ill-defined model or unrealistic parameters or whether this situation ‘fits’ in the solvency model that was used. When a case of insolvency occurs, then one could on one hand defend that this was caused by an unusual situation, an extreme event or a ‘perfect storm’, and on the other hand that the model and parameters used were unrepresentative. In the first case, no additional measures would have to be taken, in the second case, one should re-evaluate the solvency model used. However, there are no objective methods to determine which one is right and action taken after an occurrence of insolvency will be the result of a judicial or supervisory decision.

Related to this is the in actuarial literature widespread, but empirically ungrounded, decomposition of risk into stochastic volatility, model and parameter uncertainty and structural uncertainty. Under this decomposition, the stochastic volatility is assumed to coincide with the normal random fluctuations in frequency or severity of the occurrence of events. Model and parameter uncertainty should be the risk that models are ill-defined and that measured parameters are not representative for the future. The structural uncertainty has been described as high impact, low frequency events (such as unexpected judicial judgements and sudden health improvements) (Cairns, 2000). It is not clear how the occurrence of an event or the consequences to which model and parameter uncertainty relate, should be identified. One could argue that the modelling process ‘creates’ model uncertainty and that measuring ‘creates’ parameter uncertainty. One could model the modelling process in order to quantify the model uncertainty but that would leave uncertainty about the model of the modelling process. Secondly, it is impossible to relate the results of a set of observations to one of the three risk decompositions in an objective way and therefore to make an empirically justified distinction between these risk elements. The origin of this unfortunate decomposition is not entirely clear to us but it seems to be rooted in Bayesian statistics. Nowadays, the use of these decompositions seems widespread and persistent as it is used in many research reports on solvency[viii].

Concluding, the first intuitive approach to define the empirical validity as the realisation of the desired situation is not a proper definition of the empirical validity of a solvency norm. The underlying desired situation of a probability based solvency norm is not open for empirical verification or falsification.

Therefore, we conclude that a solvency norm does not imply a guarantee or policyholder’s right for meeting future obligations, not for 100% and not for any other percentage.

4.2 Validity as orientation of action towards the norm

In the previous subsection, we have argued that empirical validity of a solvency norm cannot be defined as the conformity to the desired situation of the norm because the conformity to the desired situation is in no way empirically verifiable. Then, what is decisive for the empirical validity of a solvency norm? To answer this question, we have to look at the actual effect that the norm has on solvency policies of insurance undertakings. What does actually happen to their solvency policies when a solvency norm is accepted as a legal norm?

The discussion of the first European solvency requirements showed that the first European solvency norm was the final piece of a long-lasting political process. It required some time for insurance undertakings to adjust their solvency policies and financial positions towards these new norms. Only if there is enough unanimity on what is customary in practice or, at least, what is perceived as feasible in practice in the near future, unanimity of the legislative powers will be obtained and a solvency norm can be established. Therefore, the reality is that solvency norms only codify what is already customary in insurance practice or what is likely to be feasible in a short period of time.

The actual effect of the establishment of a solvency norm on policies of insurance undertakings should therefore not be overestimated. Probably the largest majority of insurance undertakings formulate their solvency policies in a way corresponding to legal norms not out of obedience to the norm, but either because the environment approves of the conduct and disapproves of the opposite of the conduct, or merely as a result of unreflective habituation. And presumably a limited number will formulate their solvency policy in a certain way with the primary reason that they regard it as prescribed by the legal propositions. This motivation is of course essential for the actual emergence and continued operation of any norm, but it is by no means necessary that all insurance undertakings do so from this motivation. It is furthermore not necessary that all insurance undertakings that accept a solvency norm as a legal norm, will always act in accordance with that belief at all times. This obviously also depends on the economical environment and the capacity of an institution.

We conclude that decisive for the empirical validity of a legal solvency norm is the orientation of solvency policies of insurance undertakings and not in the realisation of or conformity to the desired situation of the solvency norm. For a probability based solvency norm (and probably any other solvency norm that has as an underlying goal meeting the insurance undertaking's obligations), the realisation of or the conformity to the desired situation is not empirically verifiable. What is empirically verifiable is the orientation of action, of which the establishment of a solvency norm is the ultimate factual result. The establishment of the norm confirms what is customary and it represents the unanimity of the legislators to enforce this practice and to orient to equal solvency policies. We could therefore say those probability based solvency norms are oriented towards equitableness of probability or risk.

For example, suppose that a probability based solvency norm is implemented by means of a regulatory impact analysis, whereby the impacts of adverse scenario's, prescribed by law or by supervisory authorities, are aggregated into a minimum required solvency margin. Then, the goal of a probability based solvency norm is that policyholders, regardless of the specific asset liability management, policies and risk profile of their insurance undertaking, obtain the same level of shock resistance. Application of such a probability based solvency norm will for example lead to the situation that insurance undertakings can, among other risks, absorb a decrease in stock prices of 25%. If such a situation occurs, then the available solvency margin for market risk can be used without decreasing the technical provision. The form of equitableness is equal risk, equal shock resistance, or, to use Campagne's expression, equal safety. Shock resistance implies how well a financial institution is capable of absorbing shock, without stating something on the probability of the occurrence of these shocks in the future.

The orientation does not guarantee that insurance undertakings will always act conformable to the established solvency norm; it only means that they are oriented in that direction. Prudential concerns play an important role in the formulation and the establishment of a solvency norm, but they are never the primary ground of it. It is possible that due to external events the application of the norm eventually results in an inability to act in accordance to the legal norm and in an inability of meeting obligations but is it impossible if there would be a legal norm without the necessary unanimity of the legislative powers. Therefore, the orientation towards a solvency norm does not guarantee that individual obligations of financial institutions are met.

The minimum solvency margin, which is accepted as just, does not necessarily have to be similar to the required solvency margin needed for an individual financial institution. Whether a deviation from the minimum solvency margin is reasonable in practice depends on the judgement of the judicial power or the supervising authorities. The orientation towards a norm on the required solvency margin will have as a consequence that there will be less incentives to deviate from that norm, which from an individual prudential reason could be called reasonable, and to involve this reason in the deliberation process. Formulating a norm on the minimum required solvency margin does not remove the necessity to meet the individuality of financial institutions.

5 CONCLUSIONS AND DISCUSSION

In this paper, we investigated probability based solvency norms and their validity. The relevance of this investigation is provided by the increasing application of risk based solvency models within credit institutions (Basel II) and insurance undertakings (Solvency II). As these models are increasingly being used for regulatory and internal capital requirements, the question arises what actually happens within the insurance industry if probability based solvency policies become more compulsory. What is the relation between the solvency norm established by legislators and the actual capability of insurance undertakings to meet their obligations?

The well-known distinction between positive and normative statements provided the basis for our analysis of probability based solvency statements. We showed that the meaning of probabilities differ when they are used in a normative and in a positive statement. Positive statements are descriptive statements on something that exists or does not exist. They can either be true or false and probabilities are used to express the reliability of these positive statements. Normative statements express judgements of what can or should be and they are aimed to prevent or product action of organisations or individuals. At the moment that they are expressed, normative statements cannot be verified or falsified, and because of that we are inclined to say that normative statements are subjective. Probabilities in normative statements are interpreted as mathematical frequencies.

This analysis was applied to solvency norms and we showed that probabilities are used as mathematical frequencies. Analogous to the validation of normative statement, we observed that the validation of solvency norms at the moment they are expressed is highly problematic. Even after a large number of years, the empirical validation defined as the realisation of the desired situation of the solvency norm, is at least problematic. We argued that backtesting techniques that are presently available are unreliable except when a very large number of observations is available. Therefore, empirical validation defined as the realisation of the desired situation of the norm is highly problematic.

What does this mean for the establishment of solvency norms for insurance undertakings? The primary foundation of the establishment of solvency norms lies in the practice of insurance undertakings. A legal solvency norm is the final piece of a long-lasting political process; legal solvency norms codify what is already customary in insurance practice or what is likely to be feasible in a short period of time. The establishment of a solvency norm therefore confirms what is customary and it represents the unanimity of the legislators to orient to equal solvency policies. We concluded that a probability based solvency norm orients policies towards equitableness of risk.

The orientation is not a new phenomenon. The historical development of the European solvency requirements is oriented towards equitableness of risk. With the research by Campagne, who formulated a probability based concept of safety, the first steps to equitableness of risk were taken. The first European solvency norms are based on equal percentages of technical provision and other quantities for all insurance undertakings. The new solvency norms that are now being developed under the Solvency II project will not change this orientation and is in our opinion not a revolutionary new approach to risk management and solvency. Instead, history shows an evolutionary development where solvency margins are formally rationalised and solvency norms develop from factor based to probability based norms. Solvency II will result in a next step towards the equality of risk of insurance undertakings.

This view presented above, where we interpreted legal solvency norms as the final result of a process of converging solvency policies of insurance undertakings, which is also known as ‘positive law’, disregards the idea that laws can also be interpreted in the light of their purposes, which is also known as ‘legal instrumentalism’. It could be argued that some laws and guidelines are not based on current practice but are used to influence practice in a certain direction. These laws and guidelines therefore become instruments of supervisory authorities and governments. Whether these instrumental laws will be successful can not be answered in advance. The interpretation of solvency norms as instrumental laws was not addressed in this paper.

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[i] "In every system of morality, which I have hitherto met with, I have always remark'd, that the author proceeds for some time in the ordinary ways of reasoning, and establishes the being of a God, or makes observations concerning human affairs; when of a sudden I am surpriz'd to find, that instead of the usual copulations of propositions, *is*, and *is not*, I meet with no proposition that is not connected with an *ought*, or an *ought not*. This change is imperceptible; but is however, of the last consequence. For as this *ought*, or *ought not*, expresses some new relation or affirmation, 'tis necessary that it shou'd be observ'd and explain'd; and at the same time that a reason should be given; for what seems altogether inconceivable, how this new relation can be a deduction from others, which are entirely different from it" (Book III, Part I, Section 1, Of virtue and vice in general).

[ii] In Essays on some unsettled questions of political economy (1844), Mill wrote "… With respect to the definition in question (…) it seems liable to the conclusive objection, that it confounds the essentially distinct, though closely connected, ideas of *science* and *art*. These two ideas differ from one another as the understanding differs from the will, or as the indicative mood in grammar differs from the imperative. The one deals in facts, the other in precepts. Science is a collection of *truths*; art, a body of *rules*, or directions for conduct. The language of science is, This is, or, This is not; This does, or does not, happen. The language of art is, Do this; Avoid that. Science takes cognizance of a *phenomenon*, and endeavours to discover its *law*; art proposes to itself an *end*, and looks out for *means* to effect it".

[iii] In The Scope and Method of Political Economy (1891), Keynes distinguished among "… *a positive science* … a body of systematized knowledge concerning what is; a normative or regulative science…[,] a body of systematized knowledge discussing criteria of what ought to be…[,] an art… [,] a system of rules for the attainment of a given end". He furthermore comments that "… confusion between them is common and has been the source of many mischievous errors".

[iv] In An essay on the nature and significance of economic science (1932) Robbins wrote "… Unfortunately, it does not seem logically possible to associate two studies in any form but mere juxtaposition. Economics deals with ascertainable facts; ethics with valuations and obligations. The two fields of enquiry are not on the same plane of discourse. Between generalizations of positive and normative studies there is a logical gulf fixed which no ingenuity can disguise and no juxtaposition in space or time bridge over (…) Propositions involving the word 'ought' are different in kind from propositions involving the verb 'is'".

[v] There are indications that there is a common ground for Campagne's work and the earlier mentioned use of probabilities in coastal engineering design. Van Dantzig, a well-known Dutch statistician who was the co-founder of the Dutch 'Mathematisch Centrum', was head of the research team who advised the Delta Commission. His team made some important calculations that were used by the committee for the costs for strengthening the coastal defence. Engelfriet and Campagne, who both founded the actuarial section at the University of Amsterdam, are both influenced by van Dantzig.

[vi] This organisation was renamed to Committee of European Insurance and Occupational Pensions Supervisors (CEIOPS) in 2003.

[vii] This organisation developed to the Organisation of European Co-operation and Development (OECD) in 1961.

[viii] A similar empirically ungrounded decomposition of risk is the possibly even more tenacious decomposition into diversified and non-diversified risk, which will not be discussed here.