

Risk

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The concept of risk is fundamental in the social sciences. Risk appears in numerous guises, from theoretical modeling of financial decisions to determining the social consequences of expanded nuclear power usage. Despite this importance, the precise definition of risk depends on the context and application. Common usage is derived from insurance applications where risk represents the possibility of loss, injury or peril. This definition is reflected in various risk assessment and management applications, ranging from social and psychological risk to environmental and bio-hazard risk, where units of measurement for risk vary with context. In contrast, financial economics associates risk with the possibility that the actual return for a security will differ from the expected return. This financial risk is typically measured using the variance or standard deviation of historical return from the mean return, a definition of risk that includes both positive and negative outcomes. Key theoretical notions such as risk aversion and the risk-return tradeoff employ this definition. Where only the possibility of financial loss is of concern, as in value-at-risk applications, measurements are evaluated using the left tail of the relevant probability distribution.

Risk, Uncertainty and Perception

The evolution of methods for the identification, assessment and management of risk have

played a central role in the progress of civilization. In ancient times, religious beliefs were important in reconciling the risks confronting a society. Appeals to the gods by the priesthood, prophecies from the oracle, chanting by the shaman were all methods of passively dealing with risks encountered. The development of scientific, mathematical and probabilistic methods during the Enlightenment permitted risk to be more actively identified and assessed. This advancement encountered a philosophical quandary concerning subjective and objective interpretations of probability. More precisely, the objective interpretation views probability as inherent in nature. Logic, scientific investigation and statistical analysis can be used to discover objective probabilities. In contrast, subjective probabilities quantify an individual's belief in the truth of a proposition or the occurrence of an event and are revealed in an individual's choice behavior. Such probabilities can vary across individuals due, say, to differing degrees of ignorance about the event of interest.

Debate over subjective versus objective probability reached a peak around the time that Frank Knight (1885-1972) introduced a distinction between risk – where the objective probability of an event is at least measurable – and uncertainty – where the probability is not knowable and has to be determined subjectively. This terminological distinction between risk and uncertainty has now faded from common usage as the subjectivist approach has gained prominence supported by seminal contributions from Frank Ramsey (1903-1930), Bruno de Finetti (1906-1985) and Leonard Savage (1917-1971). Attention has shifted to whether subjective beliefs derive from intuition or are only realized in choice behavior. The intuitive approach leads to a focus on the perception of risk, a concept often employed in psychometric and sociological research. Development of the choice-theoretic approach to subjective probability was facilitated by the

expected utility function introduced by John von Neumann (1903-1957) and Oskar Morgenstern (1902-1976) in a classic work of social science, *The Theory of Games and Economic Behavior* (1944). The choice-theoretic approach has sustained the modeling of decision making under uncertainty that is a central component of modern economic theory.

Risk in Economics

Prior to von Neumann and Morgenstern, mathematically formal neoclassical economic theory was based on certainty or perfect foresight. Consideration of risk in decision making could be found in the less formal approaches of Frank Knight, John Maynard Keynes (1883-1946) and Irving Fisher (1867-1947) that have contributed to a range of future contributions and perspectives on the impacts of risk in economics. Knight's recognition that uncertainty could be handled by the insurance principle led to contributions on the importance of moral hazard and adverse selection in decision making under uncertainty. By explicitly recognizing the "caution coefficient" that measures the difference between the mathematical expectation and the price that will be paid for a gamble, Fisher laid the foundation for later contributions in mean-variance portfolio theory. The numerous contributions by Keynes on risk and uncertainty range from the *Treatise on Probability* (1921) to the *General Theory of Employment, Interest and Money* (1936). Disciples of Keynes, such as George L.S. Shackle (1903-1992), argue against the use of probability theory to model decision making under uncertainty. Similarly, the failings of the ergodicity assumption are an important Post Keynesian critique of mathematically formal economic theory.

In addition to the diverse approaches to risk generated by Knight, Keynes and Fisher, the

application of mathematical formalism in economic theory has also produced impressive progress. Using preference orderings over state contingent commodities, Kenneth Arrow (born 1921) and Gerard Debreu (1921-2004) were able to extend the neoclassical economics of Stanley Jevons (1835-1882), Leon Walras (1843-1910) and Alfred Marshall (1842-1924) to include decision making under uncertainty. This development follows naturally from using the choice-theoretic approach to subjective probability developed by von Neumann and Morgenstern. The utility of a certain outcome is replaced by the expected utility, calculated using known probabilities and the utilities for a set of random outcomes. The known probabilities are notionally determined by direct observation of previous choice behavior. Using this approach, while there is no formal distinction between risk and uncertainty, risk is usually associated with the variability of random outcomes and uncertainty with randomness. Sensitivity to risk is measured by comparing a certain outcome to a random outcome with the same expected value. Risky outcomes are measured in income, dollars or returns and can take both positive and negative values.

In financial economics, the expected utility framework has been applied to the problem of determining how to optimally combine individual securities into a portfolio of securities. Using an expected utility function specified over the expected portfolio return and variance of portfolio return, Harry Markowitz (born 1927) and William Sharpe (born 1934) were able to demonstrate that the variability or risk of a portfolio can be further divided into two components: firm specific risk which is diversifiable and non-systematic; and, market related risk which is systematic and not diversifiable. Applying this to the tradeoff between risk and return, it is demonstrated that only increases in the systematic risk of an individual security will be rewarded with higher

expected return. Hence, it is only that portion of the total variability of a security's return that cannot be diversified away that warrants higher expected return. A measure of systematic risk – the beta of a security – is provided. Beta can be calculated as the slope coefficient in a least squares regression of individual security return on market return: the ratio of the covariance between the individual security return and the market return divided by the variance of the market return. More recently, a variety of risk measures have been developed to deal with limitations of variance of return and beta. These new measures include: expected regret; conditional value at risk; and, expected shortfall.

Risk in Other Social Sciences

In social sciences other than economics, risk is usually identified with only negative outcomes. Units of measurement vary and can include the annual death toll, deaths or injuries per hour of exposure, loss of life expectancy, loss of working hours, accidents per mile driven, and crop loss per storm. A wide range of risk definitions and risk models are employed including: the classical approach based on objective probabilities, adapted from engineering and medicine; the choice-theoretic expected utility approach employed in economics; and, the risk perception approach popular in sociology and psychometrics, where it is explicitly recognized that risk depends on cultural and individual perceptions that can differ from expert or objectively specified risk estimates. Because a variety of different negative outcomes can be of interest, measures of risk vary with the consequences involved. For example, in the classical approach, risk is defined as the loss or hazard if the event occurs times the probability the event will occur. In other words, risk is a combination of exposure and uncertainty. However, when risk involves an event such as

death, then risk relates only to the probability of the event occurring.

In many situations in the social sciences, the application of objective probabilities to determine risk is problematic. Though it is possible to specify the relative frequency of a negative outcome from past data, the data is often limited and the estimated risk can be less than objective. In addition, because risk depends on the context, there is room for disagreement over the selection and measurement of relevant consequences. This poses problems in studies of perceived risk where individual perceptions are compared with ‘real risk’ obtained from expert or objective estimates. Early studies on risk perception were concerned with determining whether there were significant deviations between individual risk perceptions and expert estimates. If such deviations were present, this provided support for the presence of heuristics and other sources of probability judgment bias. Further research has revealed that risk perception is a more complicated phenomenon. For example, risk perception depends on the target selected. This is manifested in ‘risk denial’ where individuals perceive risk to the general public from, say, alcohol or nuclear waste, to be greater than perceived risk to the individual or the individual’s family.

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