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Freedom and the Law
50 Years After the Publication of Bruno Leoni's Masterpiece

Liberty and Risk Regulations

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The information you have is not the information you want
The information you want is not the information you need
The information you need is not the information you can obtain
The information you can obtain costs more than you want to pay

Peter Bernstein, Against the Gods

1. Introduction

One of the striking features of contemporary socio-economic debate is the growing importance of the concept of risk and risk management. The discipline, which formerly concerned mainly the games of chance (Bernstein 2004), now covers almost all areas of life (Hood et al. 1992, Power 2004). Since the mid-80s, category of risk is becoming increasingly important in social and economic life. It is a subject of a rapidly growing number of books and articles, and even entire scientific journals not only in finance, but also in such remote areas as: psychology, health care, politics, public security, social policy, juridical science, international relations and environmental protection (climate risk).[1] In economics and finance have developed a number of quantitative risk management methods. Of great importance in the social sciences is as Beck's thesis (1992), according to which the concept of risk plays such a large role in modern worlds, that we can talk about the formation of a risk society. People are more and more aware and averse of different types of risk. They want to feel that public institutions and private corporations are capable to identify, measure and deal with all important sources of risk (Power 2007). This need is reflected both in the expectations of the society (expressed and fueled by the media industry) and in the regulatory environment of business activities. In addition, the State is more and more often perceived as a risk management institution of last resort, safeguarding individual citizens and whole societies from serious hazards (Giddens 2008).

The reasons for this increase in the importance of risk in public discourse are complex and multidimensional. First of all, in the twentieth century, there has been a significant change in the way people view the risk. Previously, the world was largely perceived as a domain of chance. The results of taken ventures were seen as dependent on a pure (good or bad) luck. This was largely due to the fact that for centuries people have been exposed to the rare but unpredictable

[1] Since the late 90's formed such journals devoted to risk management, as: *Due Diligence and Risk Management*; *Healthcare Risk Management*; *Risk Management*; *Energy and Power Risk Management*; *Australia Institute of Risk Management Journal*; *International Journal of Risk Assessment and Management*; *Opthalmic Risk Management Digest*; *Australian Risk Management*; *Operating Room Risk, Management*; *Strategy and Risk Management*; *Public Sector Risk Management*; *Community Risk Management and Insurance News*; *Risk*; *Operational Risk and Compliance*.

natural disasters, which affected particularly the yields from agriculture – the base of traditional economy. Today, people are much less inclined to recognize their actions in terms of inevitable fate which cannot be predicted nor prevented. The development of quantitative risk analysis has led to the conviction, that risk is something that can be identified, measured and – what is most important – managed. It is also important that the primary source of risk (both in ordinary and catastrophic scale) is no longer wayward nature, but the man. In other words, people are more interested in risk, because they are often (even if unwittingly) responsible for its emergence and in some cases they are capable to reduce it.

The issues of risk and risk management regulations became even more pressing with the recent economic crisis of 2008. Many people believe – not without good reasons – that its outbreak was caused by greed of financial institutions and their faulty attitude towards risk. The primary source of the problem – it is often said – is the deregulation of financial sector, which took place in the 80's. On the other hand, the establishment of more and better risk management regulations is seen as a solution.

I will try to show that international regulations of business activities (such as Basel rules, Sarbanes-Oxley Act, Solvency program) based on modern quantitative risk management methods unintentionally cover some but not all types of risk. As a result, they are forcing entrepreneurs to analyze and manage only selected types of risk, but in very sophisticated way. Because the intellectual resources of each company are limited, this leads to underinvestment in the analysis of other types of risks, mainly unmeasurable, but nevertheless important uncertainty (in Misesian terminology: case-probability). In consequence, these regulations put unnecessary constraints on private economic activity, which not only restricts individual freedom, but also limits the entrepreneurial innovation and undermines the smooth operation of market mechanisms. To make matters worse, these regulations do not necessary reduce the risk, but change its nature. Companies covered by them are overprotected against some risk factors (i.e. currency depreciation), but remain defenseless against other, which became evident during the recent economic crisis.

In the course of my argument, I'll start from the presentation of the discussion about the nature of probability and the distinction between its objective and subjective interpretations. The second section will link together the concepts of probability with the development of modern econometrics. Third section will briefly look at the historical development of theory of risk: from the remarks of Frank Knight, through the findings of Harry Markovitz to the formulation of famous CAPM model (Capital Asset Pricing Model) and modern risk management methods: VaR and RAROC. My goal here is to show that the development of the theory of risk was based on econometric methods which in turn were based on objective interpretation of probability (in Misesian terminology: class probability). Forth section is devoted to modern risk management regulations. Subsequently I will move to critique of these regulations by claiming that they are not able to meet the excessive expectations that lie behind them. In the last section of the article I will draw some conclusions for libertarian policy.

2. Risk and probability

The notion of risk refers to some events in the future, about which we don't know whether they will occur or not. The size of risk with respect to a given event depends simultaneously on two things: likelihood of its occurrence and possible impact. For instance, the risk of tripping on the sidewalk is something completely different than the risk of becoming a victim of flood, even if the former happens much more frequently than the latter. Risk management is generally focused on unlikely but potentially catastrophic events. Most convenient way of handling risk is the language of mathematics. The severity of various events can be expressed in monetary terms (i.e. associated loss), whereas their likelihood can be formulated within the framework of probability calculus. Although, combining these two numbers into single benchmark is far from easy, a much more important issue is the need for interpretation of quantitative measures of risk. Probability calculus is an abstract sub-field of mathematics and as such concerns random variables and stochastic processes, which have no direct counterparts in real world. To be able to assign probabilities to risk factors, we must first determine how to understand probability in the context of actual not mathematical phenomena. Contrary to what might seem, there is no good, widely accepted answer, how such a translation should look like. This is where the philosophy of probability is applied. In this chapter, the main interpretations of probability will be discussed and their implications for risk analysis and management.

2.1. Probability as a degree of belief

At a time when Knight made his distinction between risk and uncertainty, modern interpretations of the concept of probability have not yet been developed. Initially, the prevailing view was the causal determinism. According to this belief, formulated by famous nineteenth-century French mathematician Place Laplace, there the empirical world is fully determined and the randomness is at most a cognitive illusion. This means that there is no direct link between probability calculus (which is about hypothetical random events) and the reality.

One of the first attempts to develop a more refined interpretation of probability was undertaken by J.M. Keynes in his Treatise on probability (1921). He stated that the probability does not apply to factual events (e.g. dice rolls), but our knowledge of these events. The more reasons we have to believe that particular event is likely to occur, the greater is the probability of its occurrence. More precisely, Keynes defines probability as a degree of justification of a particular belief, relative to some body of evidence. Although this kind of probability is always held by someone (after all it is a property of human knowledge) but in Keynes's view it still has an objective character, since each rational person with the same evidence should always have the same degree of belief in a particular statement. This objectivistic approach has not received much support. However, the idea that probability is a property of human beliefs turned out to be inspiring. Another eminent economist – Frank Ramsey has advanced the concept of Keynes and developed a renowned theory (Ramsey 1931) which defines probability as a subjective degree of belief of a particular person with respect to given statement (i.e. that particular event will occur). The measure of this type of probability is readiness to bet on a that statement at some odds (for closer description see Box 1. below). The general idea is that subjective probability is expressed not in declarations but in actions (e.g. making a bet).

Box 1. How to measure one's degree of belief?

Frank Ramsey proposed a following procedure for measuring the degree of one's subjective belief in a given statement. First, let us assume that person A is a researcher who wants to examine the degree of belief of person B in some event E. For this purpose, A needs to persuade B to make a bet on E under following conditions. The task of B is to choose a number q (betting quotient). After she does so, the person A chooses the stake S (however S must be small compared to wealth of B). If the event E occurs, the person B receives an award in the amount of (1-q)S. The catch is that the stake S can be negative, so the person B does not know whether she bets on occurrence or absence of event E. For this reason, in the best interest of B is to choose such a betting quotient q, which reflects her subjective belief about the likelihood of E.

Source: Own description based on Gilles 2000

A key element of the subjectivist concept of probability is The Ramsey-De Finetti Theorem.[2] It states that the quotients in a hypothetical betting situation satisfy the axioms of classical probability theory, provided that they have been determined coherently[3]. In other words, the subjectivist interpretation of probability is consistent with the mathematical theory of probability.

2.2. *The frequency theory*

At the same time, when Ramsey and De Finetti were working on subjective theory of probability, the Austrian mathematician Richard von Mises (the brother of Ludwig von Mises) developed an alternative – frequency interpretation of probability. He assumed that the subject of probability theory are mass (i.e. a nation population) or repetitive (i.e. coin flipping) empirical phenomena.[4] This type of events are characterized by two patterns:

- one cannot predict the outcome of its next manifestation (the principle of randomness);
- with increasing number of repetitions, their average value move towards a certain fixed amount – a frequency (the Law of Large Numbers).

Relying on these observations Mises defines probability as a limiting frequency of an event, formally: $\lim_{n\to\infty}\frac{m(A)}{n}$, where m is the number of instances of a particular event w n-element space. This definition, in contrast to the subjectivist approach of Ramsey and De Finetti does not refer to the beliefs of people, but to incidence of objective empirical phenomena. For this reason, it is more in line with intuitions associated with the mathematical meaning of probability, which evolved from the analysis of games of chance.

One of the objections, which can be raised to the theory of Richard von Mises is that it is too narrow. It does not apply to such cases as the probability of individual future events (i.e. that Barack Obama will win re-election) or the probability of some inductive reasoning. Mises's answer was that this is an advantage rather than drawback of his theory. Common notion of probability is vague and covers very distinct objects. Therefore we need to use different terms for their identification. Mises states that the probability as such (in original sense) relates to mass or repetitive events. While in this respect we can agree with Mises, there is much more serious problem with his theory. Namely, frequency definition of probability presupposes, that for relevant collections of events (collectives) there are limiting frequencies at all. This presumption is far from obviousness, given that these collections as empirical are by necessity finite. Although

[2] Bruno de Finetti was an Italian mathematician, who in 1930 independently of Ramsey developed the idea of subjective probability.

[3] Bet is coherent always and only if the participants of a betting situation (described in box 1) cannot choose the quotients at which one of them wins, regardless of whether the event occurs or not.

[4] This kind of phenomena Mises named "collectives", but this term didn't gain much popularity.

the use of infinite model of the finite phenomena is quite a common procedure in science, particularly physics, but still it needs justification, which is often not easy. In other words, in order to use the frequency interpretation of probability one needs to demonstrate that the phenomenon analyzed is subject to the law of large numbers. Nevertheless, the Mises idea was favorably received and eventually gained wider acceptance than the probability as a degree of belief. This topic will be further discussed in the next paragraph. Finally, it is worth to mention that the frequency theory, just as the subjective theory satisfies the axioms of classical probability theory (see Gilles 2000).

2.3. Probability and econometrics

Science, for which the problem of interpretation of probability is the most important is the statistics and econometrics. One of the primary objectives of these disciplines is to formulate methods to uncover some regularities in certain data sets. Typically it is assumed, the these data are generated by some stochastic process. This means that the they do not reflect the studied phenomenon directly, but with some indeterminacy – element of randomness. At this point, the issues of probability are involved. First, there is a problem of how to interpret probability (in particular, what does it mean that a variable takes certain values with some probability distribution[5]) to be able to use the calculus of probability in statistical or econometric reasoning. Second, one may ask, how to understand a sentence (a conclusion from statistical inference), which says that with such-and-such probability (say 95 percent) there is a particular relation between two or more random variables. The development of econometrics was inherently linked to resolution of both problems.

The first econometrician, who was aware of the importance of these issues was Ronald Aylmer Fisher. This eminent mathematician was the author of groundbreaking concepts of estimator bias, Fisher information and statistical significance testing (p-value) methodology. He also formulated the theory of experimental design, according to which if we are not sure whether the outcome of an experiment affect the statistical factors, that we did not take into account the need to repeat this experiment in as diverse conditions as possible. Fisher was likewise familiar with the works of Richard von Mises and appreciated the idea of probability as frequency. However the assignment of this definition to empirical collectives raised his objections since in practice it is difficult to find sufficiently numerous populations that satisfy the law of large numbers. As an alternative Fisher proposed to apply probability to potentially infinite statistical populations, for example, when the relevant data are generated by an easily repeatable experiment. This postulate was found more convincing than the original Mises approach, however the more refined Fisher's idea to link empirical observations and probability through so-called fiducial inference turned out to be unsuccessful.

While R. A. Fisher was the one who introduced the frequency interpretation of probability to statistics and econometrics, but its dissemination has been caused by two other mathematicians: Jerzy Neyman, Egon Pearson[6]. They linked the probability calculus with decision theory in the frequentionist framework and developed such fundamental statistical concepts as: I and II type errors and the null and alternative hypotheses. Their main achievement is however the formulation of one of the major econometric methodologies, namely: maximum likelihood estimation. This methodology consists of – in general – selecting such values of the model parameters that their distribution makes the observed data most likely (probable) to observe, given the dataset and statistical model. One of the applications of maximum likelihood methodology

[5] The difficulty lies in the fact that neither variables nor probabilities are directly observed. The only thing we can register is limited number of realizations of random variables.

[6] Egon Pearson was the son of Karl Pearson – the leading British statistician.

is the estimation of the parameters of probability distribution, which is of great importance in risk management. One of the aspects of this approach is discussed a little closer in the box 2 below.

Box 2. How to obtain probability of yet unobserved event?

Suppose that we have a stochastic process that generates results from a given range with some probability distribution. This may be, for instance, the activity of investors in the stock market and daily returns on the listed assets. Let us also assume that we have access to the sample of data obtained from this process. It is easy to retrieve probabilities of certain outcomes simply by calculating relevant frequencies. The problem is that we cannot learn in this way the probabilities of rare outcomes, because, by definition, there are not enough (or even any) of them in the sample. How can we overcome this problem? We may try to determine the exact shape of the probability distribution of all possible outcomes of that stochastic process. Assuming that we know the type of distribution in question (e.g. normal distribution), it is sufficient to estimate some of its parameters basing on available data (in case of normal distribution: its mean and variance) to be able to reproduce it entirely. With this knowledge it is easy to calculate probabilities of arbitrarily rare outcomes, even those that did not appear in a sample (for example because they represent events that have never occurred).

This method plays a major role in the analysis of financial risk. In this case, a given risk factor is treated as a stochastic process that generates events (i.e. the ups and downs of asset prices) with different effects on the value of a particular asset portfolio. Risk analysts are usually interested in estimating the likelihood of rare catastrophic events that could significantly undermine the value of the entire portfolio. Available historical data are typically not sufficient to directly calculate the frequencies of such events, so the estimation of entire probability distribution is applied. This method requires the adoption of three difficult to justify assumptions:

1. that the probability distribution of the outcomes of the stochastic process take a specific form (usually the most convenient normal distribution);
2. that the observed data were generated by the same stochastic process (with the same parameters);
3. that the future will look like the past.

The consequences of these assumptions will be further discussed in the article.

Contrary to what might seem, not only the frequency definition of probability has played a role in the development of econometrics. Even in seventeenth century, Thomas Bayes has formulated a mathematical theorem, which has laid the foundations of statistical inference based on the subjective interpretation of probability. This theorem allows to calculate the conditional probability of A given B, knowing what is the probability of B given A.[7] In particular, 'A' may represent a theory of some events (for example about their probability distribution) and 'B' – empirical data concerning these events. Using Bayes theorem, we can estimate the conditional (*a posteriori*) probability of the initial theory, taking into account the collected data. Then we can modify this theory, so that its conditional probability was as high as possible. If we had virtually infinite dataset, the result of this procedure would not differ from the maximum likelihood estimation (described in box 2). However in case of restricted dataset, the choice of the initial theory (prior probability distribution) influences the final result of Bayesian reasoning.

[7] Formally, the Bayes theorem says that: $P(A|B) = \frac{P(B|A)P(A)}{P(B)}$

This theory is interpreted as a subjective probability of some events.8 Bayesian methodology was initially considered a standard model of statistical inference. Only with formalizing the concept of frequency probability (by Richard von Mises) and through the work of Fisher and Neyman and Pearson, econometrics became dominated by the frequency modes of inference. In the 70's, however, largely due to works of Arnold Zellner, there was a renaissance of interest in Bayesian econometrics, which continues till today. It still plays a minor role in risk management theory and practice.

2.4. Conclusion – the Janus-faced probability

Janus is a Roman god – patron of beginnings and transitions, whose name was given to the month of January. He is usually represented with two faces, one looking back into the past and the other looking forward into the future. Janus serves as a recognized personification of dual nature of probability.[9] The first face of probability is a frequency probability, concerning large collections of homogenous (mass or repetitive) data. The second face is a subjective probability reflecting the degree of belief of a person in an event, on which data are infrequent or missing. This distinction is of great, though sometimes overlooked importance in finance and risk management, as in different financial issues different type of probability applies.

Frequency definition is applicable when we have a precise question, and a large collection of data, allowing to answer it. An example might be the market risk of maintaining a particular, very liquid asset in a portfolio for a short period. We can value this asset on mark-to-market basis and look at daily price movements. There are a lot of data in such situation so one can easily calculate virtually any frequency. In this way, however, we can measure only a very short-term risk. If we wished to examine the risk of maintaining a particular asset on the balance sheet for the period of a year, we would have to analyze the historical annual rates of return of this asset, which are by definition scarce. More complicated question often require more complex and harder to obtain data. The farther we look into the past in search for them, the less confidence we can have that they are homogenous. In such cases, it is worth to use other information than that contained in the data, such as theoretical considerations, educated intuition, etc. In other words, it is worth to treat probability as something subjective, which of course should not be understood as an expression of the "anything goes" attitude.

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[8] This subjective probability may represent either some kind of prior knowledge (e.g. resulted from theoretical considerations) or ignorance (non-informative prior). In the latter case usually the uniform probability distribution of relevant variable is used. The choice of prior probability distribution for Bayesian inference is however a very disputable issue.

[9] This simile (of probability to Janus) was introduced by Hacking (1975) and since then was often repeated in modern literature (see: Gilles 2000).

3. The development of theory of financial risk

3.1. The remarkable distinction

The development of the theory of financial risk started from the Knightian distinction between risk and uncertainty. The first of these concepts refers to the situation where the result of action depends on the realization of a random event, which cannot be fully predicted, but its probability distribution is known. The second possible situation – the situation of uncertainty – is similar but with the absence of information about these probability distribution. Knight's distinction has carried a rather pessimistic message; namely that the risk, which can be evaluated and managed concerns a relatively small class of events, while the most important socio-economic problems are marked with pure uncertainty. In particular, the entrepreneurship - according to Knight - relies mostly on overcoming uncertainty (due to accurate judgment about consumer preferences) not risk.

A similar view was shared by many contemporary philosophers and economists, including Ludwig von Mises who – referring to his brother's (Richard) results – distinguishes class and case probability. The first concept relates to homogeneous classes of events (e.g. games of chance, errors in production processes) and can be operationalized in the form of frequency. The latter concept relates to single, often human-dependent events in the future. The probability of such events cannot be evaluated through quantitative analysis, in particular the theory of risk, but is the subject of a people's beliefs. Mises agrees with Knight that entrepreneurship involves ability to anticipate consumer preferences and use of thus arising opportunities for profit. This ability is a kind of intuition which cannot be scientifically algorithmized but is verified through the market selection process. This view was shared to some degree even by Keynes, who in his Treatise on Probability (1921) criticizes the classical theory of probability, claiming that it is of little use in reality. In response to criticism Keynes makes symptomatic statement (1937):

> By "uncertain" knowledge I do not mean merely to distinguish what is known for certain from what is only probable. The game of roulette is not subject, in this sense, to uncertainty .... The sense in which' am using the term is that in which the prospect of a European war is uncertain, or the price of copper and the rate of interest twenty years hence, or the obsolescence of a new invention (...). About these matters, there is no scientific basis on which to form any calculable probability whatever. We simply do not know!

Uncertainty about a particular event means that you cannot calculate its probability (or its expected outcome) because of lack of historical data. Uncertainty, however, is not equivalent with complete ignorance. Both intuition (i.e. resulting from experience) and theoretical investigation may shed some light on the relevant likelihood. This type of probability is more subjective than objective in nature.

3.2. The development of modern theory of risk

The widespread, in the first half of XX century, belief that the economy is generally the domain of uncertainty and the risk is more the exception than the rule temporarily hampered the development of the theory of financial risk. This belief began to gradually change with the development and dissemination of the statistical methods in economics. It became possible to analyze more and more phenomena through the probabilistic perspective.

Finally, in 1952 Harry Markowitz (the future Nobel Prize winner) published the seminal paper Portfolio selection, which paved the way of financial risk theory. Article was devoted to the formulation of the optimal investment strategy. Markowitz began with the observation that investors in the securities market are simultaneously seeking to maximize return and minimize risk. Then made a revolutionary statement that a good approximation of a security risk may be the variability of its returns. Markowitz assumed that although the rate of return on virtually all assets vary across periods, but their probability distribution takes the form of Gaussian curve with a possible to calculate expected value and variance (the higher the expected rate of return, the higher the variance). On this basis, by means of linear programming he described a whole family of efficient portfolios, which yield maximum return at a given level of risk or carry minimum risk at a given rate of return. It is worth to mention that the Markowitz approach assumes in particular that there exist an objective independent of time probability distribution of certain rates of return from assets and that this probability distribution can be estimated on the basis of historical data. The revolutionary idea of Markowitz was to operationalize the Knightian risk concept and to characterize it through a single measure, namely the volatility of rate of return from assets.

The next step in the development of the modern theory of risk management is the formulation of the general model of financial market – CAPM (Capital Asset Pricing Model), which allows the pricing of assets on a basis of Markowitz portfolio selection theory. It was based on very restrictive assumptions, for example that all agents are perfectly rational, market is in a equilibrium and that the rates of return on assets and their variances are known and do not change over time (which was, incidentally, consistent with generally accepted efficient-market hypothesis). Some of these assumptions were weakened with the development of the model, but it is still based on presumption that statistical parameters of the assets are correctly perceived and reflect the likelihoods of future states of the world (the comprehensive overview of the topic can be found in Merton, 1990). Despite this limitation, mean-variance framework evolved into mainstream theory of finance and a foundation of standard methods of risk management, such as Value-at-Risk (VaR), Sharpe ratios or risk-adjusted return on capital (RAROC).

4. Modern financial risk regulations

Despite its intensive development, the theory of financial risk for a long time remained very academic discipline. For a long time, no compelling reasons were seen to implement systematically the modern risk management methods in financial institutions. Banks operated in a highly regulated and rather stable environment, characterized by relatively low volatility of the main risk factors. This situation began to change in the late 70's, as a result of the following factors:

- Since 1971 as a result of a departure from the Bretton Woods system, exchange rates have become floating and the currency risk emerged.
- In the eighties, the variability of energy prices has increased significantly, which became a source of new risks;
- At the same time, there has been trade liberalization and financial market deregulation, which increased competition among financial institutions. Banks needed to engage in new risky ventures, such as: currencies, commodities, securities and options trading.
- Fluctuations of inflation in the late 70's and 80's have caused a crisis of credit and deposit operations, which led to the identification of interest rate risk.

The growth of importance of risk management was also caused by the emergence of derivatives, which enabled disaggregation of different types of risk present in the existing financial products. The increase in scope and complexity of the risk taken by financial institutions resulted in the emergence of the need to use new advanced tools for measuring and managing risk. Simultaneously, the paradigm of financial supervision began to change. While earlier the focus was primarily on controlling the current activities of banks, as the time passed more and more emphasis was put on standardization and control of banks' own risk management systems (Field, 2003).

In March 1987, Merrill Lynch launched one of the world's first risk management departments. This happened shortly after the bank suffered large losses on mortgage-backed assets. In the following year the Basel Committee, grouping representatives of the 10 (now 27) central banks or financial supervision institutions of developed countries, has announced the first edition of the Basel rules (Basel I) determining the capital adequacy requirements of international commercial banks. To each type of financial assets has been assigned weight reflecting the associated credit risk (from 0 in the case of government bonds of OECD countries, up to 100 for most corporate bonds). Banks in turn were required to maintain the capital reserves proportional to the amount of risk-weighted assets in their balance sheets (capital adequacy ratio was set to 8 percent). The introduction of the Basel regulations has spurred the development of standardized methods of risk management in banks. In 1993, the bank J.P. Morgan has published later widely accepted set of risk measurement tools RiskMetrics. It was one of the first versions of technique Value at Risk (VaR), which consists of calculating how much capital can be lost due to an unfavorable outcome of a particular operation at a given level of risk. In 1998, Chase Manhattan (now part of JP Morgan Chase) on the basis of VaR has developed a widely used transaction management system called RAROC (Risk Adjusted Return on Capital).

Box 3. The virtues and vices of VaR.

Value-at-Risk is widely used modern method of risk management, so it is worth to discuss it a bit more closely. VaR is calculated for a particular asset and it consists of three steps:

1. First we need to estimate a profit and loss distribution, which shows all possible returns of the analyzed asset with assigned probabilities in a given period. To do this we need to systematically examine what will be the return of the asset in the various market conditions and then analyze what is the probability of these conditions. Thus we obtain probability function of the total return on assets, in relation to various possible events in the market. The greater is the number of underlying risk factors, the more the procedure is complicated.
2. In the second step, we need to choose the percentile, which reflects the frequency of a particular return of the asset. For example, 99 percentile marks the point on the profit and loss distribution for which a particular loss on the asset is achieved once in 100 selected units of time (e.g. days).
3. In the last step, we check what level of loss corresponds to chosen percentile. this value is dubbed as Value at Risk (VaR) and corresponds to the amount of reserves needed to cover losses that happen once in 100 periods (or in another chosen frequency).

The main advantage of VaR estimation is that this method generates a single number illustrating the riskiness of the assets. Although the choice of the percentile analyzed is to some extent arbitrary, but it can be interpreted as a measure of risk aversion. Convenience of VaR and its link with the reserves needed for protection against a certain level of risk caused that this method has become widely used by regulators. Since the mid-90s, they require that banks calculate VaR and provide a proportional amount of reserves. The problem is that the greater level of security we want to achieve (and this is the direction of the evolution of regulation), the higher the percentile must be taken into account. In this case, however, the data are usually scarce and VaR estimates became very unreliable for statistical reasons.

The reason is that when the data are abundant (for example, in case of calculating relatively low percentiles of short-term price changes of very liquid assets) VaR can be picked directly from the data. However, when the data are scarce, it is impossible to calculate appropriate frequencies and there arises a need to estimate the probability of rarely observed or even yet unobserved event (see box 2). For this purpose it is necessary to assume some form of probability distribution of relevant events and then estimate its parameters (Monte Carlo experiments are no exception). Calculated in this way probabilities are very abstract and have little in common with frequency concept of probability. Yet they are typically analyzed as if they were obtained in the same way as standard frequencies. In such cases, however, the information provided by the data should be treated with great caution and subjective interpretation of probability seems to be more suitable.

With the development of financial markets and international regulations on risk management since the mid-80s, there have been a change in emphasis in the theory of financial risk. Previously the interest was put primarily on short-term risks associated with maintaining various assets in balance sheet. At some point, managers and regulators started to pay attention to other risks, originally collected under the general name of operational risk. In 1995, the collapse of Barings Bank due to unauthorized transactions of broker Nicholas Leeson highlighted the threats of the so-called rogue trading. Shortly, other types of operational risk have been identified, in particular:

(1) legal risk, i.e. the risk of incurring losses as a result of losing a lawsuit or unfavorable administrative decision (e.g. of tax office);
(2) system failure – the risks of failure of information systems;
(3) the risk of incurring losses due to loss of reputation, or
(4) a second-order risk – the risk of error of risk measurement and management systems.

Financial market regulators are also particularly interested in a systemic risk that is the risk of collapse of entire financial system due to a very rare but catastrophic event. The problem is that the estimation of operational risk (including systemic risk) is much more difficult than the estimation of short-term financial risk. The reason is that rare catastrophes, which are the source of operational risk, do not constitute a statistical population (a collective) and there is little data on them. Therefore, standard techniques of frequency econometrics (e.g. VaR) in their case are either inapplicable or burdened with considerable uncertainty.

Despite these difficulties, regulations of risk management successively became more and more stringent and complex, as well as they began to cover a growing number of risks and institutions. The most important modern risk regulations include: Basel rules covering banks and financial institutions, Solvency framework for insurance companies and Sarbanes-Oxley Act covering large public enterprises. Their breadth is now so high that it is impossible to discuss them in detail (an excellent overview can be found in Barth, Caprio, Levine 2006). These regulations, however, have some common features (Power 2007), which unify them. First of all, in order to be able to run any financial institution, insurance company or a public corporation one needs to obtain a license from the governmental supervisory authority. For this purpose it is necessary to meet a number of conditions, such as the appropriate level of capital reserves or a specific institutional capacity, etc. Secondly, the authorized institution is obliged to use official standards of management accounting, financial reporting, internal and external auditing and also the standards of the identification, measurement and management of risk (usually with the use of the latest econometric tools, especially VaR and related risk measures).10 Thirdly, regulators have influence on organizational structures of supervised institutions, in particular by requiring the appointment of certain positions (such as internal auditor, Chief Risk Officer) and often also by approving persons who will occupy them. Fourthly, the supervisory agencies influence the valuation of financial instruments by determining the types of information that can be used for this purpose. Fifthly, the regulators determine the permissible ways of distribution of financial services, for example in order to encourage or discourage lending to specific groups of recipients.

If the risk management regulations has met the expectations placed upon them, the risk borne by the financial institutions would be much smaller, bankruptcy would become much rarer and economic crises would no longer occur. Unfortunately, this vision did not came true. In 1987 there was a major financial breakdown, which should not have happened and soon other turmoil have followed, such as Metallgesellschaft failure (1992), Barings Bank bankruptcy (1995) and Long Term Capital Management failure (1998). All this led to criticism of mainstream theory of risk and the growing interest in alternative frameworks, such as behavioral finance and Austrian theory of entrepreneurship. This has rapidly gained in importance in the face of the 2008 - 2009 global crisis.

[10] This means that the major instruments of financial information processing in banks, investment funds, insurance companies and large public corporations are imposed by the political process.

5. Criticism.

The first source of criticism of mainstream theory of risk is behavioural economics. Already in the 70's, Kahnemann and Tversky (1979) have found out that people are not fully rational in the perception of probability. They behave differently in situations, where profits are at stake (risk aversion) and where the losses are at stake (risk seeking). The perception of a given risky situation depends, however, on how it is described. Moreover, in case of more complicated risk-situations, people tend to use a rules of thumb instead of precise calculations. All this is in sharp contradiction with the mainstream theory of financial risk and initially it has not received sufficient attention. Behavioural economics has also undermined the widespread conviction that the financial market is generally efficient and not vulnerable to essentially unpredictable events, such as speculative bubbles or panics. Moreover, behavioral economists demonstrated that even in situations where we have the best data about risk factors, we are not always able to rationally use them. This is a warning for risk managers and regulators, but it does not directly undermine the foundations of the theory of risk.

Only the increasing difficulties with the extension of mainstream theory of risk on new sources of threats (operational risk and systemic risk) led to the emergence and rapid growth in importance of the new criticism, whose main representative is Nassim Taleb. He is an economist and for many years derivatives trader, who in 2007 published a famous book The Black Swan. Taleb returns to old (but recently downplayed) Knightian distinction between risk and uncertainty, and argues that the source of threats (both financial and in other spheres of life) are not only the events with known probability of occurrence, but also the title Black Swans, that is unprecedented events whose likelihood is simply unknown. Both types of threats are fundamentally different and should be dealt with in entirely different way.

The fact that we do not have the possibility to estimate objective probabilities (frequencies) of Black Swans occurrence does not mean that uncertainty in general cannot be subjected to analysis and mitigation. Taleb proposes primarily to identify Black Swans, which can affect our actions and avoid those that can harm us and expose ourselves to such, that may be beneficial. There is also a more formal way of uncertainty analysis. It is based on aforementioned subjective interpretation of probability and associated with it Bayesian econometrics. This type of inference, due to the methodological controversy developed later than the standard (frequentist) statistical methods, and therefore rarely been used in the theory of risk. Today, however, it is a legitimate field of science with many practical applications. Beyesian analysis of an uncertain event proceeds in two steps. First, the researcher formulates an apriori probability distribution (or a set of distributions) of this event, on the basis of his knowledge (e.g. theoretical investigations) and insights. Next, he modifies the parameters of this distribution using the available data, so as to maximize the likelihood that these data came from this (modified) probability distribution. This method assumes that the objective probability of a particular hazard is not known, but there are some grounds for at least a rough estimate of its rarity. Bayesian inference allows to confront this estimate with data to achieve best possible approximation of a probability of a particular threat. This method can be used to identify possible hazards and minimize potential losses through so called scenario analysis or stress testing. Not all, however, uncertain events submit to such analysis. Events without precedent, whose potential existence we cannot even guess, are beyond the reach of even the most sophisticated risk management techniques. We need to accept the fact that there are risks against which we remain defenseless.

The opposite attitude represent the modern risk management and regulatory environment which treats all kinds of threats as forms of risk in strict sense. It is worth to quote in this context the opinion of Michael Power's (2007) – one of most prominent mainstream theorists of risk management:

> "Knightian uncertainties become risks when they enter into management systems for their identification, assessment and mitigation.(…) Uncertainty is therefore transformed into risk when it becomes an object of management, regardless of the extent of information about the probability."

In line with this approach, risk regulations are forcing banks, financial institutions and corporations to manage risk using the same frequentionist framework. This surely reduces the exposition of these institutions to some kinds of risk but simultaneously exposes to even more extent to Black Swans. Firstly, the use of the latest achievements of econometrics in risk management and thus fulfillment of very stringent regulations provide a false sense of security. Secondly, the analytical resources of each organization are limited. Currently, they are almost entirely devoted to the identification, measurement and mitigation of only one category of hazards - the risk in the strict sense. Therefore there is a lack of resources to carry out uncertainty analysis, through Bayesian inference, scenario analysis, etc. Thirdly, the unifying nature of risk regulations forces banks and financial institutions to response to global threats (crises) in the same way (for example, by selling certain types of assets), which enhances their severity. In addition, a formal risk management systems (typically required by the state) can be harmful in the moment of crisis, because they slow down the response of organization and dampen innovation and natural leadership of entrepreneurs.

6. Risk and liberty

Laplace rightly pointed out that there is no such thing as risk. There are events which affect the outcomes of our action and at the same time we are not able to predict them. For some of them, on the basis of historical experience we can assign probabilities (another thing that doesn't exist in reality), by which we can calculate insurance rates. For others we have only a vague idea of what may be their likelihood and potential consequences. Yet another events remain completely unknown and will come unexpectedly. On the other hand, risks are a social constructs – an attention driving devices to express public anxieties (Power, 2007). These tensions are responded by State, which imposes restrictions on consumers, producers and markets in hope to reduce the perceived risk. Sometimes, usually in simpler cases, these regulations are effective. Often, however, they do not constitute a real answer to real threats (many of which are impossible to mitigate), but only meet social expectation that government will take some action. These regulations not only restrict individual freedom and limit entrepreneurial innovation, but – as was demonstrated – can increase rather than decrease the risk to which people are exposed. If we aim to achieve a Free-Market Society, we need to weaken the risk regulations. However, this will require changes in social attitudes to risk, especially getting used to the idea that we cannot fully protect ourselves against all kinds of risk.

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