Chapter 16
Risk and Representation: The Limits of Risk Management

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16.1 Introduction[1]

Much was debated in the past years about the causes of the financial crisis which was triggered by the collapse of the US real estate market and the implied huge losses in complex-structured credit securities by large financial institutions, mostly banks. The crisis also reveals fundamental failures in the measurement, management, and transfer of risk in the financial system as well as methodological weaknesses (to say the least) in the regulation of financial institutions. Much has been learned about the (il-)liquidity of markets and its self-reinforcing effects, but the real problem is deeper.

I postulate that there was an insufficient awareness of the role of the representation of risks (such accounting standards, risk models, or management processes) with respect to the emergence of risks, in particular systemic risks and financial crises. The wording used in public commentaries is revealing and serves as an example: In the first months of the crisis, when banks announced their first substantial write-offs on their US mortgage-based assets, the "fear of further write-downs"

[1]The topic discussed in this *chapter* is partially beyond the scope of a financial economist. Nevertheless I hope that the thoughts are stimulating. I apologize for any shortcomings and errors and bear sole responsibility. The chapter is partly based on an earlier paper of the author, written in German in early 2008, shortly after the breakout of the financial crisis, entitled "Risiken und Repräsentation. Über Krisen des Finanzsystems" (in B. Strebel-Aerni (Ed.): Standards für nachhaltige Finanzmärkte, Schulthess (2008).

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was mostly regarded as the main cause of subsequent losses suffered by the banks' shareholders, not primarily the fear of actual further losses on the banks' risky positions!

It seems that if the object of interest is sufficiently abstract or complex (or both), as in the case of risk, the specific representation is a key determinant for shaping the perception or construction of reality: Credit rating procedures, accounting rules, write-downs, risk weighting schemes, regulatory capital standards, or monetary actions play a crucial role in the process of shaping the perceived risk of the financial system, and for rationalizing the potential losses to which financial intermediaries and their claimholders, or taxpayers, are exposed.[2]

Therefore, when analyzing the events in the progression of a crisis, it is notoriously difficult to discriminate between the "real" cause(s) of the problems and their multiple, partly self-reinforcing consequences. Fair-value-based accounting rules, rating, and model-based capital standards: did they passively reveal the "true" inherent risks of the system or did they cause, or at least accelerate, the risks? Did the various supervisory measures, monetary actions, or public financial stability programs mitigate or aggravate the events? How did all that affect the behavior of the economic agents?

An analysis of these questions should rely on a framework which is rich enough to represent the financial system as a complex, dynamically evolving system. More importantly, the *perception* and *management* of risks crucially depend on an adequate (viable) representation of the financial system. A simple model of unidirectional causality (usually in the form of a linear factor model where the causality runs from exogenous risk factors to position values) may be perfectly fine in normal times, but it provides an unreliable representation of the system in a situation of stress.

But if already the knowledge reflected in the representation is inherently incomplete, how should potential actions (regulation or risk management) be designed and evaluated? Suppose a network model is regarded as adequate representation of the financial sector or a part of it—how should we regulate a network? Our everyday systems are unable in mastering traffic jams; how can we expect to get a conceptual grip for a financial crisis? The suggested measures (for example, raising minimum capital requirements for banks) are usually based on a very simple, mechanical understanding of the functioning of the financial system. But the economic agents are innovative, constantly forming new expectations and adapting their ideas and models to the new conditions of the system. Therefore, with any intervention in the system, its reactions change as well. It is well known from Heinz von Foerster's

[2] It should be noticed that the expected losses as reflected in the global financial sector potential writedowns were constantly revised upwards between 2007 and 2009; starting at some US$400 billion, the estimates ended up at some US$4000 billion in April 2009, including all banks in the USA, Europe, and Japan, and including loans as well as securities (source: International Monetary Fund, *Global Financial Stability Report*, April 2009, p. 35). A different question is how these estimates are related to the actual losses of the banking (respectively, the entire financial) system, and how "losses" are defined.

model of nontrivial machines that such a system, although deterministic in nature, is analytically undeterminable, and the reactions seem random and unpredictable.[3] But would we consider this model, which is after all a standard representation of complex systems, a useful or rather useless basis for regulating the financial system? Or are we better off by choosing a simpler representation?

A lot has been written in the recent years about the triggering moments of the current financial crisis, the weaknesses of the financial architecture, the contagion effects of the crisis on the real economy, and the effects of the stabilization measures.[4] This *chapter* begins with a few general remarks about the representation of risk from an epistemological point of view (Sect. 16.2). The specific problems regarding liquidity risk are addressed next (Sects. 16.3 and 16.4), followed by a discussion of second-order knowledge traps and their circular effects, originating from incomplete or overrated knowledge (Sect. 16.5). From this background, the significance of standards in the financial system is discussed (Sect. 16.6). The *chapter* concludes with some final remarks (Sect. 16.7).

16.2 Risk and Its Representation

What is risk?[5] When talking to an option trader, "implied volatility," "the vola smile or smirk," is all that matters: It *is* the relevant uncertainty within his or her field of activity, experience, and perception. If the stock market crashes and the implied volatility triples, he or she would not have the slightest doubt that the uncertainty in the market has risen substantially. In technical terms, his or her perception or judgment of risk is fundamentally framed by the underlying pricing model[6]: in the simple case of the Black-Scholes model, fluctuations in the economic environment must be inevitably attributed to fluctuations in "volatility"—it is the only parameter in the model which is able to capture unobservable pricing factors. An observer with a perception that is not framed by the Black-Scholes model would possibly not

[3] Nontrivial machines are characterized by a state-dependent operating system (program), where the state is determined by the input to the system. Depending on the circularity of the system's architecture, the model can be used to analyze the dynamic behavior of systems such as learning, memory, adaptive behavior, and randomness. But the model also clarifies the limited knowledge which can be retrieved from the observed in- and outputs of a system about its internal unobservable "program"—even under very simple assumptions. See v. Foerster (2003), pp. 309–313.

[4] Among the numerous and almost uncountable references, the following are particularly worth reading from a financial economist's point of view: French et al. (2010) and Acharya et al. (2009).

[5] Although widely debated, in order to simplify the discussion, we do not distinguish between risk and uncertainty in this *chapter*.

[6] Notice that an implied volatility is only defined with respect to a specific option pricing model, which in turn depends on a specific stochastic process of the underlying securities and the implied arbitrage mechanism. In the Black-Scholes model, this reduces to an assumption about the standard deviation (volatility) of logarithmic price changes.

associate the market turmoil at all to "volatility" (a purely statistical representation), but to increased demand for protection, changing risk premiums, illiquidity, impaired market confidence, technical correction, and so on.

The option pricing framework with its "implied volatility" paradigm is an instructive example how models shape the perception and judgment of individuals in their professional work.[7] Notice that the claim here is not merely that the model serves as a complexity-reducing device (which it is indeed), but defines a linguistic code. It enables a standardized, fast communication in the hectic marketplace and the settlement of economic transactions. The pioneering work by Piaget, v. Glasersfeld and others demonstrates how language (in the broad sense, including e.g. mimic expressions) affects thinking and shapes, organizes, and structures people's perception. Language therefore determines what observers observe, what they construct, what they know and accept as personal reality. Therefore, as noted previously, the "implied volatility" *is* the reality, the (possibly hidden) model *is* the reality, and the "map *is* the territory" as v. Foerster bluntly stated.[8]

Although this view seems radical and controversial, it brings a novel perspective into the modeling of financial risk which stands in fresh contrast to the common "quest for the right model" mostly encountered in the theory of finance and financial management, and nourished by the administrative validation procedure in recognizing internal risk models under Basel II. Of course, the constructed "reality" may be regarded as being wrong and the individual may fail with the used model—but this is not the adequate perspective of the cognitive process under the constructivist approach: the emphasis is shifted from the "reality" to be discovered and re-presented by an adequate model to the creation (construction) of knowledge and the formation of perception. As discussed below, this seems to be quite a fruitful—viable—approach for our discussion. The reason is that risk and randomness are abstract, not directly observable phenomena of daily life. We only perceive realized damages, losses, accidents, crises, and the like. Abstract categories require an adequate cognitive (or mental) representation.[9] Risk is traditionally represented in many different ways: as narratives such

[7] Within the social sciences literature, a similar argument (with respect to option pricing models) can be found in MacKenzie (2006), although his focus is slightly different from the constructivist perspective advanced in the text here. A general analysis of the relationship between mathematical models and realities (ontological, personal, social, and formal) can be found in Henning (2009).

[8] See Foerster/Pörksen (1998), p. 82.

[9] The term "representation" is always tricky to use in a constructivist setting. Of course, representation does not only apply to abstract categories which are not directly accessible to sensual perception, but also refers to a general epistemological category. In this chapter, the term is used to characterize a device, by which objects—whether "real" (in the traditional meaning of an objective ontological reality) or "constructed"—are made accessible to our practical experience. While our point of view is fundamentally constructivist, we do not go as far as E. von Glasersfeld's who, in the absence of an observer-independent world in itself, abandons the expression right away (e.g., in v. Glasersfeld 1996). We agree with von Foerster that the term "re-presentation" (in German: "Ab-Abbildung") is inadequate or misleading with respect to a "reality" being "presented" (see v. Foerster 2013). However, our understanding is that representation reflects a state of knowledge (or a basis for acquiring knowledge) of an observing individual.

as myths and saga, as games of chance or lotteries, and most prominently as probabilistic and statistical models. Chance even found its systematic way in performing arts and the literature.[10] In business risk management, when using checklists or early warning systems, it is interesting to notice that the representation of risk is blurred. This insight is related to a general observation by sociologist U. Beck who claims that, in the process of defining (in our terminology: constructing) risk, "[t]he dimensions of the hazard are limited from the very beginning to technical manageability."[11] In the case of financial risk management, statistical models have a long and successful history, particularly in the field of insurance, as long as large ensembles of events can be represented by sufficiently stable statistical laws (damages, mortality, etc.).

Things became more difficult in the emergence of capital market risks (interest rates, commodity and stock prices): First, they can only be incompletely diversified which implies that comovement and temporal variability of prices are an essential part of modeling. Second, with the growth of option markets, the modeling of nonlinear, possibly even path-dependent risk profiles started challenging researchers. And third, with the rapid growth of over-the-counter (OTC) markets, counterparty (credit) and liquidity risk became issues of major public concern, not only since the financial crisis.

In technical fields (IT, engineering, or architecture), accounting, or international law, "standards" have a long tradition as quality, and hence risk management devices. It is therefore not surprising that the quest for generally acceptable financial risk "standards" has emerged over the past two decades, triggered by the banks' progress in implementing quantitative risk management tools and the regulator's recognition of model-based capital standards.[12] The point is discussed below (Sect. 16.6), but it should be obvious that standards are not primarily devices to represent risk, but to recognize or even approve the representation and management of risk. Standards should therefore be regarded as second-order representations of risk.

A final aspect is important: Under the constructivist, or pragmatic, epistemological view, the objective of scientific knowledge is not to discover (or represent) an ontologic truth or reality, detached from the observer's experience. Instead, knowledge is considered a "tool within the realm of experience" which is reflected in more or less useful inventions, fictions, or (in von Glasersfeld's

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[10] A very illuminating collection of essays on this subject (in German, however) can be found in Gendola/Kamphusmann (1999).

[11] Beck (1992), p. 29; the original version was published in German (Beck 1986). Interestingly, in the English version, the quoted sentence is supplemented by the following remark: "In some circles it is said that risks which are not yet technically manageable do not exist—at least not in scientific calculation or jurisdictional judgment. These uncalculable threats add up to an unknown residual risk which becomes the industrial endowment for everyone everywhere" (p. 29). This is extremely revealing in the context of the systemic relevance of liquidity risk discussed below.

[12] At least, there are generally accepted risk management "principles" (GARP).

terminology) “viable” concepts or conceptual constructs such as actions, mental operations and structures, or theories.[13]

A model or business practice may be viable in one context but fail to be so in another. This sounds fairly trivial, but was largely overlooked in the modeling of risk. It implies that there is no horse race of models to find out which one represents the reality (a specific type of risk) in the “best” way. It has long been unrecognized that a model’s objective in risk management, and thus its required profile, is usually not identical to other applications. A model, which is used to determine the value of derivative assets, should in the first place exclude arbitrage opportunities, and must therefore take the relevant market microstructure (tradability of hedge positions, short selling opportunities, transaction costs, taxes, etc.) into account. In the case of American options, for example, it is essential to take into account the optimal early exercise decisions in the valuation model. Should the same models be blindly used for the risk management of derivatives? This is indeed common practice, although the requirements on the entire model *architecture*, and not merely on the specified parameters, are different. The American option provides a good example: For the party who has a short position in the contract, the biggest risk does not arise from the rational (optimal) exercise behavior of the counterparty, but from a possibly irrational exercise decision, whatever the reason might be—the pricing model is, however, based on optimal behavior. Another example is the assumption of continuous hedging and replication possibilities, which may be a suitable approximation for pricing, but not for modeling the liquidity risk of a market. Using stress tests in this respect is short-sighted, because these work on the level of parameter specification and risk scenarios, but the assumptions of the model and the range represented risks are not questioned. In fact, stress tests should invalidate or mutate the models’ architecture, which, for example, could be represented in the form of genetic algorithms in a more viable way.

It is not only crucial to constantly validate the objective of models, but also to be aware that models explicitly shape what we do and do *not* consider a risk within the range of a specific risk management task. Of course, we have been long aware of “model risk” in risk management, and perform many calculations and estimates using alternative assumptions from different models.

But the problem goes deeper, however, and arises from the self-referential character of the nature of risk, i.e., the risk of risk. We have to find a *risk-adequate* representation of risks, meaning a form of representation (similar to a language) of risks, which reveals the risk of representation itself and keeps the represented object “alive.” The analogy with language is useful because the linguistic sign system is not only a basic example for the representation of knowledge, but also shares many structural properties, such as self-reference and circularity: Language can be used to

[13] As mentioned earlier, von Glasersfeld strictly avoids the term “re-presentation” in his characterization of cognitive action, because he relates it to an unknowable ontological reality. However, in a less strict view, the “concepts or conceptual constructs” also require a representation, a representation reflecting a certain state of knowledge. The quoted phrases are from v. Glasersfeld (1998).

talk about language (i.e., by inventing a meta-language).[14] Of course, the linguistic rules could be constructed in a way that the language is gradually distorted or destroyed in the circular process, in a way that the ability to describe itself is abandoned. This would completely invalidate the epistemological function of language and communication. Similarly, a system which is designed for representing risks and which, through its ongoing circularity, would make the risks of the represented objects gradually disappear would be as worthless and inoperable as a language which had no ability to describe itself.[15] The inclusion of such circularity in the design of descriptive systems such as risk management in itself represents a problem that is far from trivial, as discussed in the following sections.

16.3 Liquidity as an Information Problem

Liquidity risk, and the various types of risks assigned to this category,[16] is a particularly insidious risk category because of its self-destructive impact on the information processing capacity of markets. In extreme cases, this may mean that the market mechanism generates no information at all which disables the communicative function of markets and thereby invalidates the representation of market-based security values and their risks; in a weakened form, the information capacity due to high spreads and low conditioning volumes can be so severely restricted that the information for the assessment of risk positions is too blurred and thus unsuitable. In more extreme forms, the information may even be misleading. In the context of market-based risk and accounting procedures, this represents a "second-order" problem because, in a sense, the representation of risk makes the represented "object" disappear.[17] The object disappears, but not the risk itself, and this is where the dilemma is! Therefore, returning to the question of risk-appropriate representation of risks relating to illiquidity, we are confronted with a special, yet largely overlooked difficulty: which are the relevant objects to be represented in the presence of illiquid markets?

A further loop or self-reference in the information system originates from the use of model values in lieu of the missing market values; this practice is consistent with market-based accounting principles and is recognized by supervisory authorities. This generates, in a sense, a representation problem at a higher level. At the same time, most accounting standards require depreciation of positions which are becom-

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[14] See v. Foerster (1997), p. 165 (original German edition).

[15] In his Tractatus, Ludwig Wittgenstein characterized the language as located on the very limit between the speakable and the unspeakable. I would suggest that representations of risk, e.g., by a probabilistic risk model, are similarly located at the borderline between safety and uncertainty.

[16] Two typical forms of liquidity risks are "market" liquidity and "funding" liquidity; their relationship is analyzed by Brunnermeier/Pedersen (2009).

[17] Or in attenuated form: the object (market price) which is required for the representation of risk loses its suitability or quality.

ing illiquid. Finally, financial analysts and the media need to provide information about the market valuation of the affected financial institutions. This is a nearly endless loop of self-references, which ultimately deprives the risk management system and the financial market of any information function: the system starts to produce noise rather than information.

Ultimately, it is no longer possible to distinguish between the risk of (inadequate) representation and the represented objects, and hence the representation of the risks. The often-raised question of how many secondary effects are generated "by the system itself," i.e., are fictional in nature and not related to the financial system intrinsically, seems pointless in this context. The question has no answer, because it would require a natural break at some point in the operation of the system, from where we could distinguish between the "original" problems (real estate crisis, excess leverage of the system, etc.) and the "subsequent" effects. This view is incompatible with the modern view of dynamic systems characterized by circularity and feedback effects.

A particularly strong case of circularity is associated with the interpretation of credit risk (i.e., the quality of debtors and counterparties). The criticism directed at the rating agencies shows this clearly: Should rating agencies review credit ratings based on functioning market structures and economic conditions (i.e., "conditional" reviews), or does the market expect *un*conditional reviews? The high correlation between liquidity and credit risks[18] highlights the importance of this issue. In this context, the question of the temporal (i.e., causal) relationship between credit and liquidity risk is particularly relevant. Is credit risk determined by the (il) liquidity and market frictions, or do major credit events and related information problems trigger liquidity crises? The effect may well be circular and self-reinforcing.[19]

16.4 Liquidity as a Network Problem

Liquidity risk is multidimensional; it is related to many different aspects of risk. In the context of risk management or the financial regulation, liquidity is often regarded as a separate category of risk, but from an economic point of view, a representation as superposed or second-order risk category would be more adequate. In particular, an adequate representation should also account for the *systemic* nature of (il) liquidity.

It is well known that disruptions in market liquidity are not only followed, but often even caused by coordination problems between the market participants in

[18] Some early estimates about this relationship are reported in the *Financial Stability Review* of the ECB (European Central Bank), June 2008: the reported correlation coefficient for a cross section of 10 countries is roughly 0.8.

[19] An insightful analysis of the liquidity-credit risk spiral during the financial crisis can be found in Brunnermeier (2009).

times of substantial uncertainty and financial turmoil: lack of transparency about the size and nature of counterparties' risk positions, their intended risk behavior, trading intensions, or deficits in the informational role of the price system may have self-reinforcing effects.[20]

If coordination problems matter, a network model likely represents a viable representation for liquidity risks. The key merit of this approach is the shift in the perspective from the single player down to the architecture of the network, in particular to the rules affecting the coherence of the system. Also, the network approach puts into question the ability to attribute the dysfunction or vulnerability of a system operating as a network to a clearly definable cause and to derive simple, promising stabilizing rules. The following metaphor by cyberneticist H. von Foerster (2002), p. 133, provides an apt illustration of this point:

> *If I pull a crocheted vest, and I pull the thread in one place, the whole vest unravels suddenly. Now we can say: 'At the place where I pulled, there lies the essence of the vest'. And because it is located there, the whole vest disappears when I destroy this part. What ceases to be seen here is the network of threads, the 'vest network'. In a vest network, in which a thread is connected to the others, such dissolutions can emanate from a single point; such destruction can be initiated continuously from any point. Conversely, this does not mean that the pulling point would be the location of a certain function that is now no longer available and can be identified. The system does not work anymore because damage in one place can spread to the whole thing.*

That the financial crisis was triggered by the problems on the American real estate market or structural defects of mortgage securitization should not be taken, from this perspective, as an opportunity to align the efforts to stabilize the financial system too closely with these specific factors. This is because errors with similar or perhaps even greater systemic impact could have occurred in other places of the financial system. This approach is consistent with the interpretation of various experts and stability reports of monetary authorities which indicated the fragility of the financial system at an early stage, due to various structural changes,[21] but ultimately did not foresee the initial trigger moment of the crisis in the real estate market.[22]

[20] The literature analyzing the stock market crash of 1987 has emphasized many of these problems. The informational externalities related to invisible and uncoordinated dynamic portfolio insurance strategies and their effect on market liquidity was studied in detail by S. Grossman. A selection of his papers can be found in Grossman (1989).

[21] Concerns were related to structural weaknesses and the potential insolvency of central counterparties of credit derivatives (which were the major, highly leveraged investors of US mortgages), the strong dependency between hedge funds and investment banks, cross-border and cross-currency issues in the lending process between central banks, or dysfunctions in international clearing and settlement transactions. See, e.g., Zimmermann (2007) for a discussion of the subjects in the public concern just instances before the breakout of the financial crisis.

[22] Only a few eminent economists can be credited to having foreseen a financial crisis caused by structural deficits of the US real estate market. Nobel laureate Robert Shiller is a prominent exception. Also Frankel (2006) reveals the structural weakness of the US subprime market in great detail, without implying a global financial crisis however.

The analysis of the architecture of the financial system should remain the primary concern in the future. However, the financial crisis teaches us that, in the reform of the financial system, more efforts should be directed to information and coordination problems related to the illiquidity of (apparently unrelated) market segments, and to the impaired funding and payment capacity of major counterparties. However, the "systemic" view was ignored until recently in the regulatory discussion. Reports and research papers which addressed liquidity management and requirements of systemic relevant banks, even released after the breakout of the crisis,[23] did not consider systemic aspects. Liquidity management is regarded as a completely customizable management function free from any systemic considerations or consequences. But systemic problems require systemic solutions, or at least solutions that are directed at collective actions, as postulated by Eichberger/Summer (2005) in the context of banking regulation:

If regulation aims for risk allocation across the entire banking system, then it has to stop concentrating on individual bank balance sheets. (…) A systemic approach to banking regulation is just the beginning.

This must be understood as a general device for the design of stabilizing measures for the financial system, and not just for the banks and their regulation.

To conclude, it should be emphasized that the solutions to the problems discussed in this section are not only found in systemic requirements (rules or standards for the processing of C&S transactions, a transparent market architecture for OTC transactions, etc.), but also involve rules of conduct applicable for individual institutions—as long as they are systemically meaningful. The requirement that every vehicle must have brake lights obviously represents a purely individual regulation, the need for which, however, fully results from a systemic requirement (because "I" do not need any brake lights for "my" vehicle). Therefore, rules with a systemic focus can be easily built in the traditional institutional based regulatory and supervisory framework; a good example are rules about securities' collateralization.

16.5 Limited Knowledge and Second-Order Knowledge Traps

What lessons can be drawn from the financial crisis? What are the implications of the preceding remarks? What exactly should be done for the financial system to better absorb such dysfunctions in the future? Is more capital needed for financial intermediaries, and how much?

As a matter of fact, knowledge about these issues is incomplete, and furthermore, even the knowledge *of* the knowledge is incomplete. Specifically, we know very little about what we would need to know to answer these questions. The financial

[23] See, for example, the consultation paper from the Basel Committee on "Principles for Sound Liquidity Risk Management and Supervision" (BIZ 2008).

system was not designed to be easily understood. Knowledge plays a major role for the design of modern financial markets, financial instruments, institutions, and processes—but it is not the same knowledge which is needed to understand the consequences from a complex process of financial innovation and its interaction with the financial system. Therefore, the systemically relevant knowledge is largely overrated in the financial sector.

Additional factors have contributed to an overestimation of knowledge in financial matters:

(a) The status of expertise

In the general perception, scientific competence and expertise are under control of academic researchers. In the past decades, consultants have taken over this function more and more. In contrast to the scientific experts of the past, the consultant charges high fees, and this can only be justified by delivering know-how and specific insights, i.e., by signaling competence. A side effect of this development is that this kind of knowledge is no longer publicly accessible and consequently no longer exposed to the scientific discourse. This applies of course to all areas of expertise developed outside of the scientific system, for example the research undertaken in banks, stock exchanges, and even by regulatory authorities.[24] The incurred risks for risk management should not be underestimated.

(b) The scientific process

The scientific process has an impact on the choice and nature of analyzed problems. Mathematics and statistics are essential and viable tools for the representation of risk in financial markets. But the quality of a tool, its internal logic and structure must be strictly distinguished from the constitutive properties of the object to be represented or constructed. Limited knowledge, indeterminism, or incompleteness are well accessible to the mathematical formalism,[25] but scientific "reductionism" directs mainstream research in more comfortable fields: v. Foerster contemplates on the method of inquiry employed by the hard sciences:[26]

> *If a system is too complex to be understood it is broken up into smaller pieces. If they, in turn, are still too complex, they are broken up into even smaller pieces, and so on, until the pieces are so small that at least one piece can be understood. The delightful feature of this process, the method of reduction, "reductionism", is that it inevitably leads to success.*

This implies Foerster's Theorem Number One: "The more profound the problem that is ignored, the greater are the chances for fame and success." The publication pressure, which is particularly powerful in scientific disciplines, thus led to a flood

[24] See Zimmermann (1999) for a detailed discussion of this development. The self-confidence, or arrogance, by which this knowledge is communicated to the world outside is sometimes remarkable. The wording of a white paper published by a major investment bank is revealing: "More than You Ever Wanted to Know about Volatility Swaps (But Less than Can Be Said)."

[25] By Gödel's theorem, incompleteness is even an inherent property of arithmetic systems.

[26] From "Responsibilities of Competence," in: v. Foerster (2003), pp 191–197. Originally published in 1972.

of technical results, which give the appearance of a huge knowledge, suitable for the purposes of risk management. But the formalism got increasingly detached from the nature of the problem to be analyzed, and the knowledge to be represented.

(c) Survivorship, success, and knowledge

In financial matters, it is often hard or even impossible to draw a clear distinction between signal and noise, or skill and luck, on typical statistical confidence levels. Still, success is commonly interpreted as a direct indicator of competence and knowledge. The selection process of success (*survivorship bias*) is ignored: in a system which accidentally distributes success and failure, the probability of success to survive naturally dominates the probability of failure. Self-selection makes the successful to survive, and makes them talk about their ongoing success. However, inference regarding superior knowledge is not justified. The selection process also leads complete randomness to appear like competence and knowledge to the public. If the selection process is connected to a high level of monetary compensation, people will be particularly tempted to attribute this to a high level of competence.

(d) The media and the quest for simplicity

The public overrates experts' knowledge because people have a strong desire for simple explanations of complex matters. The media eagerly respond to this desire and provide a steady stream of commentaries and statements from professionals. The search for eligible candidates is terminated if anyone is willing to give their opinions and explanations, and this process always ends successfully. Those remaining silent, because he knows that he knows little or nothing, are ignored.

In the public arena, from the point of view of the layman, expertise is also overrated because one needs knowledge to appreciate the value of knowledge. This creates a second-order effect of limited knowledge: how can ignorance be recognized and built in the architecture of observing systems? Risk management, in this respect, needs to find an adequate representation of knowledge about existing knowledge, and complementarily, knowledge of ignorance or at least the limitations of knowledge.

Notice that the argument is not about the deficits of possible representations of risk, e.g., what is typically known as "model risk" in the field of risk management. The claim is that the level of knowledge, and complementarily the level of ignorance, represented implicitly by a specific model ultimately amplifies the risks which ought to be represented.[27]

The idea can be further illustrated with an analogy to linguistics: nonrecognition of the non-expressible of a given vocabulary leads to a threat from *that* which cannot be expressed. A striking example of this dilemma is provided by Odysseus,

[27] This may sound rather abstract. An example: Metallgesellschaft in the early 1990s sold long-term commitments to deliver gasoline and hedged the exposure thereof by rolling over short-term futures contracts. The company assumed that futures markets remain in backwardation. When the futures market turned into contango, the company was forced to adjust the hedging strategy. Because of the substantial market share of the company and the illiquidity of the market, this adjustment amplified the adverse price behavior, i.e., increased exactly that risk which ought to be hedged. The company finally got insolvent. A detailed analysis can be found in Culp/Miller (1995).

who, upon entering the cave of Polyphemus the Cyclops, cunningly presents himself as "Nobody." This benefited him after he rammed a stake in the eye of the sleeping giant who was holding him as a prisoner. With his cry of "Nobody has blinded me, Nobody has tried to kill me" Polyphemus could not secure the help of the other Cyclopes. If Polyphemus had recognized the limitation, or ambiguity of his vocabulary as imposed by Odysseus, his fate would have taken a better turn.

We conclude the preceding thoughts with the metaphor of eyeglasses: as a matter of fact you need glasses to realize that you actually need a pair of glasses. Without, you cannot even come to recognize that there is another, better representation of reality, one that is associated with fewer or lesser risks. The epistemological conclusion is that you can't see what you can't see. The double negation, however, does not mean that you can see! The implication (advanced by Spencer Brown, Heinz von Foerster, or Gotthard Günther) is that with self-referential processes classical logic fails by violating the principle of double negation. This has crucial implications for the design of risk management systems, albeit ones which are barely discussed. Returning to the metaphor of the eyeglasses, the circularity and the resulting dilemma for the risk management are obvious: how can you find a lost pair of glasses without glasses?

This is not an impossible task—provided that *you know the risk* of misplacing the glasses (i.e., you know the risk of not seeing). But the possible solutions have nothing to do with traditional actions, such as correcting the lenses. Rather they could involve, for example, an adaptation of structures (e.g., keeping the eyeglasses around your neck), the introduction of standards (e.g., strict rules about where the risky object should be deposited), or the implementation of intelligent search processes (e.g., pressing an emergency button to ask someone for help). The final section deals with some thoughts about this topic.

16.6 Standards

What is the role of standards for the representation of risk? In 2009, the International Organization for Standardization released its Risk Management Standards (ISO 31000, Principles and Guidelines) which should help firms to improve the quality of their processes in terms of "economic performance and professional reputation, as well as environmental, safety and societal outcomes." The principles as well as the recent technical follow-up report (ISO/TR 31004:2013) are designed for general organizations, not specific sectors or activities. There are no specific standards for financial institutions, but general principles or best practices.[28] But obviously, international standards play an increasingly important role in international financial

[28] The use of "standard" is somehow ambiguous in the literature. In the field of law and prudential regulation, the term has a rather broad meaning (e.g., includes the principles released by the Bank of International Settlements). A decade ago, Nobel (2005) lists more than 60 standards in use in the field of international financial regulation.

operations (e.g., IT, clearing and settlement, law, accounting, audit, controlling) and shape the understanding and perception of risk.

The benefit of standards originates from the combination of commitment and flexibility. Typically, a standard defines a minimum level of quality (or regulation) that allows the individual jurisdictions enough leeway to agree upon a set of rules for specific needs. From a polito-economic point of view, a standard is usually the only way to establish rules at the international level.

Standards can be regarded as a prerequisite to the solution of several of the previously discussed issues, for example:

- Standardized approach in the representation, processing, and interpretation of information and data, and thus improved communication and coordination of decisions (e.g., accounting principles, trading statistics)
- Common terminology, definitions, and language (e.g., classification of products, risk categories, etc.)
- Reduction of technological frictions, operational inefficiencies, and therefore improved coordination of complex processes (e.g. in securities trading and settlement, payment systems, etc.)
- Mitagion of legal uncertainty by regulatory or contractual standards (e.g. netting rules, capital adequacy, collateralization)

Thus, standards seem to be promising for reducing the risks caused by various types of frictions and their implied second-order effects, i.e., the risks originating from an inadequate representation of risk. However, their overall performance may be difficult to assess.

This may be particularly true with respect to the aggregation of information. When defining a technological standard, e.g., the specification of securities numbers, less emphasis is put on information and knowledge aggregation issues than, for example, in the release of clearing requirements of OTC derivatives or capital standards of banks. Here, the administrative negotiation process involves procedures and activities (e.g., advice from experts, research, practical experience) so that the resulting standard signals new knowledge and leads to positive information and incentive effects. However, precisely the Basel II "bank capital standard" has been criticized for having destabilized the financial system and failed to prevent or mitigate the financial crisis.[29] The case illustrates that the process of establishing and implementing standards is not immune to administrative momentum and strategic private interests in negotiation. In light of the previous observations about the limits of knowledge, and knowledge of these limits, it should be considered that

- Standards determine the perceptions of the agents, both on a personal level (cognitively, psychologically) and an institutional level (e.g., through the legal and accounting framework).

[29] Admati/Hellwig (2012) provide an in-depth discussion of financial regulation, the role of banks' capital, and the safety of the banking system.

- Standards signal superior knowledge; they might negatively affect agents' incentive to process information and to acquire knowledge, or to manage or mitigate risks.
- Standards create incentives for opportunistic behavior by delegating responsibility to the standard-setting instance or authority; that is, standards are not considered as minimum quality requirements, but as defining the maximum required effort.[30]
- Standards cause, with high probability, a synchronization of the perception and behavior of agents, which decreases the heterogeneity of decisions and thereby damages the liquidity of the financial system as market coordination mechanism.

It is therefore essential that standards in the field of financial risk management are not narrowly focused on operative, or technical, matters but generate sufficient incentive for a *risk-adequate* representation of risks—i.e., forms of representation which reveal the risk of representation and keep the represented object "alive." Too far-reaching standards, however, which affect the behavior of heterogeneous agents in a unidirectional way, have the potential of having counterproductive effects by limiting or impairing market liquidity with the adverse effects discussed before.

16.7 Concluding Remarks

The management of risk in financial institutions has long been dominated by probabilistic and statistical models. This is not wrong, but incomplete. The recent financial crisis has again highlighted the limitations of a formal framework for the representation of risks, particularly if second-order effects associated with the representation of risk (risk of risk) are ignored. Specifically, the modeling and regulatory treatment of financial risks are blamed as amplifying factors of the crisis itself.

The discussion of this chapter focused on those risks which emerge from limited market liquidity. It provides a perfect case where there is a risk in the representation of risks: For example, the Basel II capital standard was conceived in view of perfectly operating markets whose associated risks can be represented by market price fluctuations and a sophisticated system of credit qualities standardized and formalized by rating agencies. Furthermore, the residual category of operational risks appeared to cover all other risks, but what about liquidity risks and how should they be treated? The unsatisfactory representation of this category is not only a symptom, but most likely the cause of some of today's problems.

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[30] A good example is the capital ratio of banks which has consistently decreased over time with the implementation of stricter and more sophisticated *minimum* capital requirements. The increasing cost of equity capital is consistently used to rationalize this trend by the banking industry. Of course, causality runs in the opposite direction—whether it is a moral hazard issue or perception bias remains open here, but the effect on the systemic risk is striking.

[31] One of the editors of this volume, Robert A. Schwartz, can be credited as one of the pioneers in this field.

In addition, until the financial crisis, there was a pronounced research deficit in financial economics for modeling and understanding liquidity as a macroeconomic phenomenon. Market microstructure theory provides an analytically and empirically rich foundation for understanding the functioning of the financial markets as institutions, practically as microorganisms: the influence of the stock exchange architecture on the price discovery process, the behavior of market makers, or the determinants of bid-ask spreads.[31] Monetary economics, on the other hand, deals with issues such as optimal control of Central Bank liquidity, liquidity requirements of banks, and their macroeconomic effects. Finally, microeconomics is interested in the behavior of individuals facing incomplete information during banking crises (*bank runs*) or panic on securities exchanges (*herding*), and analyzes the influence of regulatory interventions. But these individual elements offer no satisfying picture of the financial system as a whole, because they do not fully represent its complexity. But complexity is a major constitutive feature of the modern financial system!

Although the convergence between monetary and financial economics progressed over the past years, in particular since the financial crisis,[32] more efforts are needed particularly on the methodological side. Strong focus should be placed on the risks of prudential regulation and risk management practices—meaning the systemic role of models, standards, management processes, algorithms, etc.—and should therefore be concerned with the representation of second-order risks and their circularity.

This is less complicated than it appears at first glance, because methodologically similar issues are being intensively worked on in other disciplines. It would be interesting, for example, to take advantage of the possibilities of computer science or computational economics. In the first section of this chapter, risk management was characterized as a circular, self-observing, and self-constructive system to represent risks. A methodology developed at the computer science department at the University of Basel uses exactly the circularity of processes to improve on the robustness of processes, specifically in the case of a programming language faced with external disturbances.[33] The circularity and self-reference become manifest in the program creating a code which contains its own description. This circularity in the form of self-replication allows the program to repair itself when disturbances occur; this error-correction mechanism significantly improves the stability of the system. Self-replication and self-repair are, after all, constitutive features of biological systems and were mathematically studied long ago (e.g., by John von Neumann and others). It would be interesting to investigate the possibilities—and *failure*—of these systems for the representation of risk, and second-order risk, in the financial sector along the lines of this chapter.

[32] The work by Nobel laureate Jean Tirole, and more recently by Markus Brunnermeier (see, e.g., the referenced article) and Hyun Song Shin, to mention just a few representative researchers, is remarkable. They focus on the relationship between market liquidity and financing patterns (leverage, collateralization) to analyze contagion effects and financial stability. Shin (2010) gives an overview on this research. Shin's nomination as Economic Advisor and Head of Economic Research at the Bank of International Settlements (2014) is a promising perspective in this light.

[33] See Meyer/Tschudin (2012).