US GAO – United States Government Accountability Office, 2011: Electricity Grid Modernization: Progress Being Made on Cybersecurity Guidelines, but Key Challenges Remain to be Addressed. Washington, DC: GAO-11-117

van der Vleuten, E.; Lagendijk, V., 2010: Interpreting Transnational Infrastructure Vulnerability: European Blackout and the Historical Dynamics of Transnational Electricity Governance. In: Energy Policy 38/4 (2010), pp. 2053–2062

Varian, H.R., 2004: System Reliability and Free Riding. In: Camp, L.J.; Lewis, S. (eds.): Economics of Information Security. Dordrecht, pp. 1–15

Wendt, M., 2011: Smart Grid – eine Herausforderung aus Sicht der Standardisierung und der IT-Sicherheit oder schon „business-as-usual". In: Datenschutz und Datensicherheit 35/1 (2011), pp. 22–26

Contact

Dr. Carsten Orwat
Karlsruhe Institute of Technology (KIT)
Institute for Technology Assessment and Systems Analysis (ITAS)
P.O. Box 36 40, 76021 Karlsruhe
Phone: +49 (0) 7 21 / 6 08 - 2 61 16
Email: orwat@kit.edu

« »

Mechanisms of Systematic Risk Production

New Perspectives for TA Research?

by Christian Büscher, ITAS

Which questions have to be posed, which scientific problems have to be addressed, and also, what kind of instruments are appropriate when tackling "Systemic Risk"? If complex systems cannot be analyzed in causalistic models, then TA and Systems Analysis have to reflect, first, on theoretical approaches, assessing the basic conditions and processes related to the reproduction of systems, and second, on innovative methods, gathering data to allow testing scientific constructions against reality. The analysis of "mechanisms" might be a direction of impact for gaining insight into self-reinforcing processes, precarious couplings between systems, or between elements of systems, and, in the end, into the systematic production of risk and danger.

1 General Considerations

Systems analysis has taken on the task of comprehensively documenting the social, economic, political, legal, as well as the technical and ecological consequences of planned action in system reproduction. In Technology Assessment, Bechmann sees, for that reason, a need for new forms of reflection and analysis. "Any action which intervenes technically and planned (purposively) in the natural environment has to watch over its impacts on the environment and their repercussions on itself" (Bechmann 2007, p. 35; Translation CB). Bechmann derives this dictum from Luhmann's suspicion that there will be not less, but more interventions into the natural environment, and that society, for that reason, should generate more knowledge about repercussions (Luhmann 1986, p. 39). With the concept of "systemic risks", system-analytical considerations with respect to risk and hazards are tackled, which do not refer to the relationship of society to its natural environment alone. It is much rather quite generally a matter of the relationships between system and environment, of endangering oneself and others, and of the conditions for reproduction, which simultaneously (and thereby with a certain inevitability) can disturb or even completely endanger stability, functionability, and productivity.

The analysis of this sort of processes meets with considerable difficulties in theory formation and modelling, as well as in data acquisition and processing (see Cleeland in this issue). The analytical underdeterminedness and the lack of knowledge regarding the future behavior of complex dynamic systems in the material dimension generate experiences of complexity in the social dimension. The knowledge of the impossibility to map ecological and social systems (and partially, technical systems as well) in a causal model generates apprehensions of catastrophe in modern society – which by far exceed problems of risk assessment and dissent among experts (Japp 1997). We are just now experiencing how the stability of the ecosystems ("climate change"), the functioning of technical systems ("Tohoku earthquake/Fukushima"), or the service provision of social systems ("financial system") is being massively challenged. The stability, functioning, and services are further not impossible, but also not necessarily to be expected, and they are, above all, no longer purposefully produced and controlled through individual actions, through political decisions, or even through "good governance". Here lies the experience of (systemic) risk, when the negative development of a system has to be taken into account as self-endangerment or as endangerment of others, and the expectations of a continuation of the stability, function, or service are shaken. With the latter, the reference to what is at risk and what is risked is made explicit.

But it is still unclear which common reference problem could be considered for an interdisciplinary research of Technology Assessment and Systems Analysis. If it is a question of systemic risks, systems have to be described. Analyses can then not avoid making simplifying and specificating selections on various levels. In this purpose, Ashby's comment on operational research is helpful: "It does not attempt to trace the whole chain of causes and effects in all its richness, but attempts only to relate controllable causes with ultimate effects" (Ashby 1958, p. 97). In the following, it is to be indicated that (social) mechanisms can be promising candidates for theoretically-describable and methodically-controllable cause-and-effect relationships.

2 Autonomy and Non-knowledge

Research on complex systems repeatedly points out certain indeterminacies which let systems seem unpredictable to an observer. For our purpose we can single out at least two aspects of indeterminacies: when systems come under stress, then they generate in their *acceleration* poorly determinable system-changing processes which continue to indeterminable *tipping points*.[1]

The peculiarities of non-linear dynamics in ecological systems are known inasmuch as the impossibility of a prognosis of their future behavior becomes clear. On the one hand, the phenomenon of self-organized systems which, due to stress as an external impact, break out of a stable disequilibrium, resp., dynamic equilibrium. It is well-known that even or particularly minor causes can have far-reaching effects on a system. When this sort of process has been initiated, acceleration, velocity, direction are hardly predictable. System researchers speak of positive and negative feedback: "Dynamic self-regulating systems [...] if sufficiently stressed, change from stabilizing negative feedback to destabilizing positive feedback. When this happens, they become amplifiers of change" (Lovelock 2009, p. 52). This is why climate researchers fear a sudden, significant warming of the earth's climate, because – among many known and unknown variables – there are feedback loops which increasingly intensify a once initiated difference. Lovelock assumes, in his highly controversial GAIA theory, a reciprocal influence of living organisms and the climate.

On the other hand, the problem of the unknown tipping points arises. The paradoxical characteristics of high resilience with – simultaneously – high vulnerability make abrupt changes of state possible. Up to a critical threshold, systems can withstand stress. If this threshold is exceeded, abrupt and irreversible changes in the system are the result. These discontinuities or tipping points are, following René Thom, also called *catastrophes*. Such thresholds are also assumed in the "Earth Systems Theory", and one attempts to identify them as "Tipping Elements in the Earth's Climate System" (Lenton et al. 2008). Lenton et al. maintain that there has already been irreversible intervention in some of the systems essential for the planet – a proposition which is burdened with immense uncertainties, as even the authors admit.

It is difficult to see how TA research could compete in these respects with the specialized disciplines in climate research or in geophysics, to name only two examples. As far as I can judge, TA is dependent on the specialized disciplines' theories, methods, and their computer capacity. TA research unfolds its potential more as a reflexive mechanism, when it examines actions and decisions with respect to their consequences for the natural environment, and then again studies the changes they initiate with regard to their effects for society. Not only purposive-rational action (economic, scientific, political orientation) which produces unwanted consequences then comes under scrutiny, but also action and decision-making oriented on it – itself again purposive-rational –, which tries to minimize the consequences and itself unavoidably again produces new, unwanted consequences (Reusswig 2010, p. 54). It is here not only a matter of well-meant ideas which had been carried out wrong – the CO_2-emission trading for climate protection is an example –, but of the task of observing the blind spots in planning, management, or regulation (as of late: governance), in other words, of all types of intentional intervention in social processes for the preservation of ecological equilibria – which are known to perpetuate themselves only through disequilibria (Reichholf 2008, p. 99).

3 The Hypothesis of the Inherent Endangerment Potentials

Following these discussions, only with a somewhat different starting-point, inherent endangerment potentials of technical and social systems were and are being discussed. If one speaks of exogenous stress in connection with ecological systems, then in the case of non-natural systems – not exclusively, but primarily – endogenous endangerment potentials are of interest. As has already been noted, modern society depends on technical and social systems which realize a high degree of system-specific rationality, exclusive provision of services, and the inclusion of broad segments of the population (Mayntz 1993, p. 100). These services are brought about through a cooperation of organizational and technical processes. The number of elements which comprise a system rises accordingly, also the wealth of variants of these elements, which themselves vary and act selectively, which can entail an enormous "organized social complexity" (La Porte 1975, p. 6). Therefore, complexity, concentration, densification, and connectivity are, in various respects just as well a prerequisite for the functioning provision of services in technical and organizational systems as well as in society's functional areas. It becomes precarious whenever concentration, densification, and connectivity cross the threshold to dysfunctionality, and endanger the (pre-) conditions of their own functionality.

That was the subject of organizational research in the 1970s to 1990s (Todd, LaPorte, Charles Perrow, Scott Sagan, and others). The argument of the precarious nature of technical systems was precisely formulated to the description linear/non-linear interactions of elements and the loose/tight coupling of different components. Operations in high technological systems have to be compressed into a confined space, sealed off from the outside world through containment, and be embedded in a "nearly error-free", "high-reliability organizational design", so that the purposes planned can be fulfilled. On the whole, complexity is ever more strongly intensified through these requirements. Consequently, increased efficiency and dangerousness go hand in hand.

Not least for this reason, TA was brought into existence, because, in modern society, technologies are developed, implemented, and operated as a result of decision-making processes which are inherently hazardous. In connection with the discussion of systemic risks, it is striking that no operationalization of Perrow's theoretically plausible arguments has yet been undertaken. A multitude of authors has concerned themselves with the argument of "tight coupling" (see Halfmann, Japp 1990 or Willke, Orwat und Perrow in this study) without having transferred it into a research design which makes an assessment of potentials for danger possible. Here, too, one could ask how these couplings could be exhibited, from which point on the degree of tight coupling crosses the threshold to precariousness, and whether the potential for danger could be recognized in time (see Khazai et al. in this issue for a model of dependencies). In this respect, TA has to overcome – above all – methodological deficits.

4 Mechanism Explanations

Another direction has, to my knowledge, been too seldom explored in TA, and should be concisely touched upon here. It refers to efforts at understanding the mechanisms of the emergence, preservation, and possibly the collapse of social systems: "to explain a fact is to exhibit the mechanism(s) that make(s) the system in question tick" (Bunge 2004, p. 182). Mechanism explanations aim, in contrast to correlation propositions, at causal generalizations, and not at causal specifications (Mayntz 2005). One could make use of this for risk research. *Systemic Risk Assessment* would then have to comprise the analysis of processes which produce, maintain, or endanger a systemic relationship such as a natural, technical, or social system (Bunge 2010, p. 375). In the following, I limit myself to the examination of social processes which certainly put into effect and make use of technical processes, which, in their turn, have consequences for natural processes.

For the purpose of the assessment of systemic relationships, abstractions (elimination of factors) and reductions (specifications of factors) have to be made on various levels, if effects of the production and endangerment of a system are to be explained. One immediately finds oneself in the center of a well-established dispute in sociology which is designated as the confrontation of Methodological Collectivism/Holism – the search for regularities on the macro level – with methodological individualism – the search for regularities on the micro level (Albert 2011; Heintz 2004). Without going into the details, implications for the argument of systematic risk production can be extracted from this discussion, in that one inquires into the mechanisms which respectively bring about correlates on different system levels: either as "upward causation" of collective effects of individual actions, or as "downward causation" of systemic requirements as the conditioning of individual operations.

It is (well-)known that approaches of methodological individualism aim at explaining the emergent quality of a system through the intentional actions of individuals: "The action, or behavior, of the system composed of actors is an emergent consequence of the interdependent actions of the actors who make up the system" (Coleman 1986, p. 1312). The production of effects on the system level is accordingly based on the level of individual actions, which, in their turn, are framed by system properties ("shaped by constraints"). Individual effects can, in sum, have systemic effects. This is an argument which has considerable significance also in environmental research, and offers affiliations for technology assessment, because unintended consequences of – in a certain context – comprehensibly rational action are scrutinized. One assumes that individuals in social situations conditioned by "constraints", provided with sufficient information, could implement choices which, in their turn, can possibly lead to unwanted collective ecological problems. As examples for fields of research "individual environmental behavior" or "travel mode choice" are named (Liebe, Preisendörfer 2010).

Mechanism descriptions have been proposed to explain the aggregation of individual effects (Hedström, Swedberg 1996). The starting point for interest in mechanisms in sociology was criticism of correlation and multivariate analyses as statistical correlations between variables which, among other things, entail problems for the clear attribution of causes and effects. Mechanisms, on the other hand, should serve to explain regularities. The proposal is, therefore, to make causal reconstructions in order to explain a given social phenomenon, and to identify processes which have brought it about. Renate Mayntz proposes formulating complex historical narratives which should aim at generalizing processes. Certain initial conditions are connected with certain results. Mechanism propositions are causal generalizations about recurring processes: “Mechanisms determine how, in other words, through which intermediate steps, a certain result is brought about by a certain set of initial conditions” (Mayntz 2005, p. 208; Translation CB/RA). But in this procedure as well, selections have to be made. First, relevant initial conditions are chosen, as opposed to those held to be irrelevant or unknown, then generic mechanisms are isolated, and finally, the occurrences observed (as results) are declared to be in need of explanation, as against those which are not of interest, but were possibly also produced by the same occurrences.

Bunge proposes that one should concentrate oneself on the essential mechanisms with regard to system reproduction: “[A]n essential mechanism of a system is its peculiar functioning or activity. In other words, an essential mechanism is the specific function of a system – that is, the process that only it and its kind can undergo” (Bunge 2004, p. 193). For the problem which is of interest here, this would mean looking at the situation on the basis of system-environment relations, to understand the conditions for their reproduction, as well as the functions of the systems under consideration. It is, with that, at first no matter of the derivation of regularities on the macro level, but of describing the conditions for the possibility of system reproduction. With it, a functionalistic perspective is taken, because problems of system reproduction are considered.

As Willke’s interpretation of systemic risks in the financial system could show, there is an entire spectrum of necessary conditions for reproduction which, at the same time, can generate new hazardous situations as low-probability, high-impact events: liberalization, internationalization, global standards (Willke in this issue). In addition, there are “international finance multipliers”, as Paul Krugmann (2008) calls them – in other words, internationally-operating financial actors, who can dramatically intensify certain market trends. The hypothesis is that international financial crises are not caused by trade links in the real economy, but through financial obligations. Internationally operating common creditors generate financial obligations in a magnitude which brings entire regions in difficulties, when the former terminate their investment. That can happen in view of problems anticipated in the region, in which case money is withdrawn from the respective regions when they need it most (Kaminsky et al. 2003). This can also happen, however, when investors want to adjust their balances due to problems in one region and, for that reason, withdraw capital from completely other regions, which have little to do with the originally affected borrowers (Krugman 2008, p. 2).

It is a matter of proposing such hypotheses also for the assessment of systemic risks in other areas with critical developments, and of pursuing them. One should think of the assessment of the transformation of the energy supply system, which, through the increased use of information technologies, provides for tight couplings of various natural, technical, and social elements.

5 The Hypothesis of Systematic Risk Production

Many arguments of the contributions in this special issue offer an interpretation of the term “systemic risks” alternative to the usual assumptions of complexity and unboundedness. In all cases with a relation to social systems, mechanisms of the systematic production of risk and hazards can be discovered. The financial system, software systems in organizations, modern society’s critical infrastructure develop decision-making procedures – in the course of system reproduction – which bring about hazardous situations. Also the case of a *natural hazard* discussed by Khazai et al. is marked by decision-making processes which become efficacious as direct causes, e.g., in setting security levels and as *exacerbating factors*, e.g., in the case of a lack of preparedness.

In this sense, the conditions for the possibility of system reproduction would simultaneously be the conditions for the possibility of destruction. The term “systematic” has deliberately been chosen, in order to mark the distinction between *systemic conditions* for operating (codes, media, programs, structures) and structures which make it necessary to take risks. Social systems are not determined, but are historically and analytically indeterminable (von Foerster), and establish for themselves degrees of freedom which they can and must make use of. These degrees of freedom are inevitably connected with selection, contingency, uncertainty, and risk. “Systematic” accordingly designates a *modus operandi*: to seek, compel, normalize, absorb risk (Luhmann 2005, p. 71). The production of risk is a constituent of system reproduction, and is therefore no special case which has to be avoided. And that certainly applies not only for the economy, but also for other societal areas, such as medicine.[2] This paradox of endangerment in “normal operation” extends far beyond the question of unintended consequences of intentional action, and sets TA before new analytical and methodological challenges.

Notes

1) Concrete examples can be taken from geology. There, mass movements are observed, which take place linearly often for years, decades, or even centuries, and are therefore, for the most part, predictable and controllable. They can, however, suddenly accelerate exponentially. The point in time of the transition from a linear to an exponential movement is basically unknown. Just as unknown is the point in time of the rupture. One has to trust in probabilistic propositions in order to make – often far-reaching – decisions, e.g., the evacuation of settlement areas (Dikau et al. 2001).
2) An elaboration of the above arguments will be published in a forthcoming paper (Büscher 2011/forthcoming).

References

Albert, G., 2011: Moderater Holismus – emergentische Methodologie einer dritten Soziologie. In: Greve, J.; Schnabel, A. (eds.): Emergenz. Zur Analyse und Erklärung komplexer Strukturen. Frankfurt a. M., pp. 252–285

Ashby, W.R., 1958: Requisite Variety and its Implications for the Control of Complex Systems. In: Cybernetica 1/2 (1958), pp. 83–99

Bechmann, G., 2007: Die Beschreibung der Zukunft als Chance oder als Risiko? In: Technikfolgenabschätzung – Theorie und Praxis 16/1 (2007), pp. 34–44

Büscher, Chr., 2011/forthcoming: Systemische Risiken als Selbst- oder Fremdgefährdung? Das Beispiel ökologischer Folgen der Krankenbehandlung

Bunge, M., 2004: How Does It Work? In: Philosophy of the Social Sciences 34/2 (2004), pp. 182–210

Bunge, M., 2010: Soziale Mechanismen und mechanismische Erklärungen. In: Berliner Journal für Soziologie 20 (2010), pp. 371–381

Coleman, J.S., 1986: Social Theory, Social Research, and a Theory of Action. In: American Journal of Sociology 91/6 (1986), pp. 1309–1335

Dikau, R.; Stötter, J.; Wellmer, F.-W., 2001: Massenbewegungen. In: Plate, E.J.; Merz, B. (eds.): Naturkatastrophen: Ursachen – Auswirkungen – Vorsorge. Stuttgart, pp. 115–138

Halfmann, J.; Japp, K.P. (eds.), 1990: Riskante Entscheidungen und Katastrophenpotentiale. Opladen

Hedström, P.; Swedberg, R., 1996: Social Mechanisms. In: Acta Sociologica 39 (1996), pp. 281–308

Heintz, B., 2004: Emergenz und Reduktion. In: Kölner Zeitschrift für Soziologie und Sozialpsychologie 56/1 (2004), pp. 1–31

Japp, K.P., 1997: Zur Beobachtung von Nichtwissen. In: Soziale Systeme 3/2 (1997), pp. 289–312

Kaminsky, G.L.; Reinhart, C.M.; Vegh, C.A., 2003: The Unholy Trinity of Financial Contagion; http://www.nber.org/papers/w10061 (download 7.4.11)

Krugman, P., 2008: The International Finance Multiplier; http://www.princeton.edu/~pkrugman/finmult.pdf (download 17.5.09)

La Porte, T.R., 1975: Organized Social Complexity: Explication of a Concept. In: La Porte, T.R. (eds.): Organized Social Complexity: Challenge to Politics and Policy. Princeton, NJ, pp. 3–39

Lenton, T.M.; Held, H.; Kriegler, E. et al., 2008: Tipping Elements in the Earth’s Climate System. In: Proceedings of the National Academy of Sciences 105/6, pp. 1786–1793

Liebe, U.; Preisendörfer, P., 2010: Rational Choice Theory and the Environment: Variants, Applications, and New Trends. In: Groß, M.; Heinrichs, H. (eds.): Environmental Sociology – European Perspectives and Interdisciplinary Challenges. Dordrecht, pp. 141–157

Lovelock, J., 2009: The Vanishing Face of Gaia: A Final Warning. New York

Luhmann, N., 1986: Ökologische Kommunikation. Kann die moderne Gesellschaft sich auf ökologische Gefährdungen einstellen? Opladen

Luhmann, N., 2005: Risk: A Sociological Theory. New Brunswick, NJ

Mayntz, R., 1993: Große technische Systeme und ihre gesellschaftstheoretische Bedeutung. In: Kölner Zeitschrift für Soziologie und Sozialpsychologie 45/1, pp. 97–108

Mayntz, R., 2005: Soziale Mechanismen in der Analyse gesellschaftlicher Makro-Phänomene. In: Schimank, U.; Greshoff, R. (eds.): Was erklärt die Soziologie? Methodologien, Modelle, Perspektiven. Berlin, pp. 204–227

Reichholf, J.H., 2008: Stabile Ungleichgewichte: die Ökologie der Zukunft. Frankfurt a. M.

Reusswig, F., 2010: The New Climate Change Discourse: A Challenge for Environmental Sociology. In: Groß, M.; Heinrichs, H. (eds.): Environmental Sociology – European Perspectives and Interdisciplinary Challenges. Dordrecht, pp. 39–57

Contact

Dr. Christian Büscher
Karlsruhe Institute of Technology (KIT)
Institute for Technology Assessment and Systems Analysis (ITAS)
P.O. Box 36 40, 76021 Karlsruhe
Phone: +49 (0) 7 21 / 6 08 - 2 31 81
Email: christian.buescher@kit.edu

« »

Instructions for Authors

Authors are requested to observe the following instructions when preparing manuscripts for submission to TATuP.

Length of contributions: The maximum number of characters of a *printed page* in the journal “Technikfolgenabschätzung – Theorie und Praxis” is 3,500 characters (without spaces). The length of a contribution depends on the section in which it appears. More detailed information is provided by the editorial office.

Abstract / introduction: Contributions under the *main theme* of an issue or in the sections *TA-Konzepte und -Methoden (TA Concepts and Methods)*, *Diskussionsforum (Discussion Forum)* and *TA-Projekte (TA Projects)* should be preceded by a concise abstract, summarising the significant points of the paper. The abstract should not exceed 780 characters (without spaces).

Figures, graphs and tables: Figures and tables should be both embedded in the manuscript and supplied separately from the first version of the manuscript. All figures and tables should have a caption and source and must be numbered separately within the text. If created by the author, please use the phrase “Own compilation” to indicate the source.

Format: Tables should be supplied in *Word*, graphs in *Excel* and figures in *Adobe Illustrator* or *PowerPoint* format. Please contact the editorial office early if the material is only available in other formats. For reasons of page design and layout, the decision on the final size and location of the figures and tables in a contribution lies with the editorial team.

References / bibliography: Cited references are listed alphabetically at the end of the manuscript. In the text the citation should appear in parentheses (e. g. Bauer, Schneider 2006); in the case of a direct quotation the page number has to be included (e. g. Maurer et al. 2007, p. 34). Citations in the reference list should be formatted according to the following examples:

Monographs: Wiegerling, K., 2011: Philosophie intelligenter Welten. Munich

Articles in journals: Fink, R.D.; Weyer, J., 2011: Autonome Technik als Herausforderung der soziologischen Handlungstheorie. In: Zeitschrift für Soziologie 40/2 (2011), pp. 91–111

Chapters in books: Mehler, A., 2010: Artifizielle Interaktivität. Eine semiotische Betrachtung. In: Sutter, T.; Mehler, A. (eds.): Medienwandel als Wandel von Interaktionsformen. Heidelberg

Websites and online publications: iRobot Corporation, 2011: One Robot, Unlimited Possibilities. iRobot 510 PackBot. Bedford, MA; http://www.irobot.com/gi/filelibrary/pdfs/robots/iRobot_510_PackBot.pdf (download 30.3.11)

Contact: If the relevant section allows for providing contact details, the following information should be included: *Title, name and full address of the institution, including URL where applicable.* In the case of multiple authors, no more than two contact persons should be named. The contact persons can decide whether to publish their phone/fax number or e-mail address.