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A classification system for different types of research methods in risk science

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Abstract
Different types of research methods are used in risk science. Examples include the "scientific method" ("the hypothetico-deductive method"), interviews, surveys, experimentation, analysis, simulation and statistics. It is also common to distinguish between more high-level method characteristics or categories, such as being quantitative, qualitative, descriptive, analytical, theoretical, normative, applied, fundamental, conceptual and empirical. This paper presents and discusses a classification system for risk research methods and categories of such methods. A main logic of the classification system is the distinction between research aiming at i) describing and understanding aspects of the world, and ii) research aiming at enhancing the instruments used to obtain i). For both i) and ii), the importance and role of rationalism – reasoning and argumentation – is highlighted. The system is constructed to help users to properly design their research, by pointing to relevant types of research methods.

Keywords: Risk science, research methods, conceptual research, empirical research, classification system

1. Introduction

When discussing research methods on risk, it is our experience that many students and scholars think about the "scientific method" ('the hypothetico-deductive method'), as well as more specific approaches and methods such as interviews, surveys and statistics. However, further thinking and discussions, quickly lead to a long list of methods, covering also methods like observational studies, experimentation, simulation, modeling, and quantified risk assessment.

Textbooks in social sciences provide categorizations of research methods, distinguishing, for example, between qualitative and quantitative methods, but there does not seem to exist a comprehensive categorization (classification) scheme applicable for all types of methods used in risk science. Research methods on risk extends beyond the social sciences. As discussed in Hansson and Aven (2014) and Aven (2020), risk science relates to all main categories of sciences: nature (natural science), ourselves (psychology and medicine), our societies (social sciences), our own physical constructions (technology, engineering), and our own mental constructions (linguistics, mathematics, philosophy). Risk science is here understood as the practice that provides us with the most justified knowledge (beliefs) that can be made, at the time being, on subject matter covered by the risk field/discipline (Aven and Thekdi, 2022). This field/discipline comprises relevant researchers, research, scientific journals and conferences, scientific and professional societies, and educational programs. The knowledge relates to concepts, principles, models, theories, approaches and methods for understanding, assessing, characterizing, communicating and handling risk (fundamental risk science), as well as knowledge about the risk (and its understanding, assessment, characterization, communication and handling) associated with specific activities (applied risk science) (SRA, 2018; Aven, 2020). A number of different types of research methods are used in risk science. The main aim of the paper is to obtain a structure (classification system) for these methods. It is

beyond the scope of the work to provide detailed descriptions of the various methods. What we look for is a logic clarifying main categories of methods used in this science, covering the distinction between qualitative and quantitative methods, but also common method categorizations such as being descriptive, analytical, theoretical, normative, applied, fundamental, conceptual and empirical.

A main point addressed with the system is to what extent the methods support research aiming at i) describing and understanding aspects of the world, and/or ii) research aiming at enhancing the instruments used to obtain i). "Instruments" are here used in a broad sense to include concepts, principles and methods. The level of generality varies considerably for both i) and ii). The issues in relation to i) could range from a study of a specific technical system to general characterizations of phenomena and processes in society. Similarly, the issues in relation to ii) could range from methods used for assessing risk in specific settings to general principles for assessing, communicating and handling risk.

Note that we use the term "research methods" broadly in this paper, encompassing specific techniques and methods, but also broader research approaches and methodologies. Experiments, fieldwork, case-studies and surveys are examples of such broader approaches that can comprise different methods of data collection and analysis.

The paper is organized as follows. First, in Section 2 we provide a brief review of common categories of risk research methods. From this basis, we present in Section 3 the announced classification system. Section 4 presents some examples illustrating the classification system. In Section 5 we discuss the suitability of the system and some related challenging issues. The final Section 6 provides some conclusions.

The paper has a focus on risk, but is also applicable to related concepts such as safety, vulnerability, resilience, reliability and uncertainty.

2. Review of some common main categories of research methods

Simple searches in academic databases and web-based sources reveal numerous ways to categorize and label different types of research and research methods. While a comprehensive review of this literature is beyond the scope of this paper, the aim here is to highlight some common high-level categories often encountered in this type of literature.

Textbooks and university courses, on research methods in the social sciences, typically distinguish clearly between methods that deal with quantitative and qualitative data. Although there has been increasing acceptance of mixing these types of methods in many fields, quantitative and qualitative methods have often been viewed as irreconcilable due to their roots in fundamentally different epistemologies (Stoppard, 2002). A related distinction is between structured and unstructured research (or fixed and flexible research design), where unstructured research is mostly linked to qualitative methods and structured research to quantitative methods (Kumar, 2011; Robson, 2024). The distinction between quantitative and qualitative methods is also evident in many textbooks on risk analysis methods (e.g. Aven and Shital (2024) and Rausand and Haugen (2020)).

It is common to also distinguish between different research purposes (Kothari, 2004; Kumar, 2011; Robson, 2024). Examples of such research purposes are descriptive, exploratory, correlational, explanatory, diagnostic, evaluative and hypothesis-testing. Although these are not classes of methods per se, they are often linked to research methods. For example, exploratory research is typically associated with qualitative and flexible methods (e.g. case-studies, interviews and participant observation) while correlational research and hypothesis-testing are associated with more rigid and quantitative methods (e.g. sample surveys and experiments).

In our experience, it is often taken for granted that research methods primarily are about the collection and analysis of data and observations. Kothari (2004) contrasts such empirical research with conceptual research, which relates to the study of abstract ideas and theories through reasoning. Similarly, Ato et al. (2013) distinguish between empirical, theoretical, instrumental and methodological research where the three latter types relate to the development of theory, measuring instruments and methods.

MacInnis (2004) categorizes research that analyses and develops theory through reasoning as conceptual and non-empirical. She contrasts

this with conceptual and empirical research, highlighting that research dealing with data typically has a conceptual component in the form of theories and hypotheses. Main approaches associated with the conceptual and non-empirical research are four types of conceptual thinking: envisioning, explicating, relating and debating (MacInnis, 2011). Such approaches of reasoning are also central in carrying out fundamental (basic, pure) risk research, while empirical methods are typically more dominant in applied risk research (Aven, 2018).

From an operations perspective, Meredith et al. (1989) present a classification system for research methods that captures both empirical and conceptual research. In their system, the methods are distinguished based on whether they provide direct observation of reality, people's perceptions of reality, or artificial reconstruction of reality. The second dimension of the classification scheme relates to the epistemological underpinnings of the methods, including axiomatic, empiricist, and interpretative approaches. Logical reasoning and normative and descriptive modeling are methods placed under axiomatic and artificial reconstructions of reality, while physical modeling and simulation are reconstructions of reality from an empiricist perspective. Similarly to the work of Meredith et al. (1989), we will in the following present a method classification system applicable for risk research.

3. The classification system

The classification system is based on the following basic ideas and principles, illustrated in Figure 1:

- The research is divided into two main categories when it comes to purpose, i) and ii) as introduced in Section 1.
- Rationalism, in form of reasoning and argumentation, is fundamental to all types of research and is used in all methods.
- On a high level, it is distinguished between two main categories of research methods: empirical-based and conceptual. The conceptual is about mental representations and handling of ideas, and typically covers elements such as: envisioning (identifying and revising) new ideas, relating (differentiating and integrating) ideas,

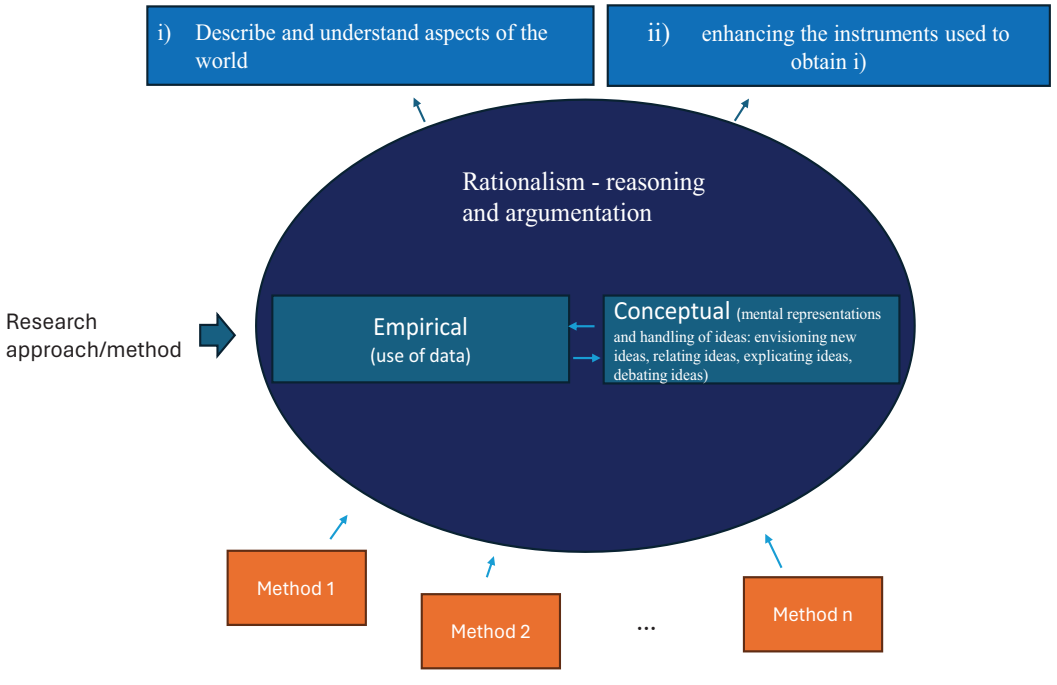

Fig. 1. Classification system for research methods in risk research

explicating (delineating and summarizing) ideas, debating (advocating and refuting) ideas in line with MacInnis (2011). Empirical-based methods are about the collection and analysis of data, typically guided by some theoretical/analytical framework.

- Risk research uses both methods, with different weights on each of them depending on the type of research. For the i) type of research, the empirical part is commonly the central one, but there are always also conceptual elements. In the case of ii), the situation is commonly the opposite, with a strong conceptual part and varying degree of empirical elements.
- The research method is supported by knowledge on statistics, social science methods (e.g. interviews, surveys), simulation, etc.

The research and the research method can be mainly quantitative or qualitative. Even if the research is based on a quantitative analysis, there will commonly be qualitative aspects involved, for example, related to the establishment of suitable assumptions. Conceptual research is mainly qualitative. It can also be based on quantification, for example, when comparing the results of two risk assessment methods. The evaluation of the results would, however, in most cases include qualitative considerations to reflect all relevant quality aspects.

We can talk about descriptive research in relation to i) but not ii). We can study how some instruments actually work in practice, which is of type i), as a support for developments of type ii). Analytical research is seen as contrast to descriptive research. Whereas the latter research aims at describing an aspect of the world as is, analytical research uses facts and information already available, and analyzes these to produce new knowledge. It can be viewed as a subset of conceptual research as here defined when it deals with abstract ideas and concepts.

Theoretical research relates to the development of theories that describe and explain aspects of the world, in line with purpose i). It is mainly conceptual. Methodological and instrumental research are aimed at ii) and include both conceptual (development) and empirical (testing) methods.

Research can be either applied or fundamental (basic, pure). Applied research seeks to establish knowledge for a specific application or case, whereas fundamental is mainly concerned with more generic knowledge applicable across applications.

The distinction between applied and generic (fundamental) research is often highlighted in risk science. Consider a work of type i) concerning how people perceive risk related to a specific activity, for example, nuclear power. A survey is conducted. The research method is both conceptual and empirical. Further, the method is generic (fundamental), although the research is applied, addressing a specific type of activity and context. We see the importance of distinguishing between the research method and the research as such. The research methods will always be generic to some extent but often adapted to suit a specific application.

4. Some examples

In this section we discuss some examples of types of studies commonly used in risk and safety science, the goal being to illustrate the ideas presented in the previous section. See Table 1. First, we consider "The scientific method" ("the hypothetico-deductive method"). It comprises the following four main steps (Wolfs, 2009):

i) Observations/descriptions of a phenomenon (an aspect of the world)
ii) The formulation of a hypothesis (model) to explain the phenomenon, for example using mathematical/probabilistic relationships
iii) Use of the hypothesis to make predictions, for example related to the results of new observations
iv) Experimental tests to verify or falsify the hypothesis.

Statistical inference is the common framework for carrying out this method. "The scientific method" combines empirical and conceptual elements. The conceptual part includes development of the hypotheses and models (item ii) and the interpretation of the results (iv).

The second example concerns a study of some hypotheses based on interviews and/or surveys. Such studies are commonly conducted in the social sciences. There is a strong empirical part as

represented by the results from the interviews/surveys, but there are also conceptual elements present, for example, concerning the formulation of the hypotheses, the interpretation of the results, and the debate (advocation or refusal).

The third example is a different type of research compared to examples 1 and 2. Here the aim is to develop suitable concepts, principles and/or methods. The research method is mainly conceptual, with all elements as shown in Table 1. There is, however, also an empirical part, related to current understandings, experiences and use of these concepts, principles and/or methods. The degree to which this part is emphasized varies considerably, in some cases, it is a main focus, in others, it is not an issue at all. If the empirical part is based on interviews/surveys, it would be supported by generic knowledge about these methods. For the conceptual part, various methods provide support, including divergent, comparative, and integrative thinking (MacInnis, 2011; Yadav, 2010).

The next example relates to a risk assessment of a specific activity/system. Also, this study is a mixture of empirical and conceptual elements. The conceptual part comprises issues concerning the conceptualization and characterization of risk, as well as model development, for example, of event trees and fault trees. The study makes use of reliability and risk assessment theory as found in textbooks in the field.

The final example is a review of works on a specific topic. There is an empirical part; the publications included in the review, and there is a conceptual one, covering all the elements of

Examples of specific methods/study types used in risk and safety science	Empirical component	Conceptual component	Examples of supporting methods
'The scientific method'	Observations, data analysis	Developing hypotheses and models, Determine theoretical implications of the results	Statistics, probabilistic modeling
To study some hypotheses based on interviews and/or surveys	Results from interviews/surveys, data analysis	Formulation of the hypotheses interpreting results and debating	Interviews, surveys, statistics, qualitative data analysis techniques
Develop suitable concepts, principles and/or methods	Data covering current understandings, experiences and use	New or adjusted ideas; envisioning, relating, explicating, debating	Interviews, surveys Divergent, comparative, integrative thinking
Risk assessment of a specific activity/system	Use of reliability data and accident statistics	Conceptualization and characterization of risk. Establishing models, for example event trees and fault trees	Reliability and risk assessment theory
Review of works on a specific topic	Data from publications, descriptive analysis	Envisioning, relating, explicating, debating	Systematic literature review methods, IT tools and databases

Table 1. Examples of studies illustrating the logic presented in Section 3.

conceptual research, such as delineating and summarizing. The work builds on modern IT tools to assist in screening of relevant publications and is based upon generic methods for conducting systematic literature reviews.

5. Discussion

The perspective adopted in this paper is that for research conducted within risk science, the high-level research approach/method used is a combination of conceptual and empirical research. Thus, when conducting such research, a description of the approach/method adopted for the research should describe the main elements of both the conceptual and empirical parts, as illustrated in Section 4. In addition, supporting methods should be highlighted.

If we study publications in risk science, many have a goal that is related to the purpose i), describing and understanding aspects of the world, but there is also a substantial amount of work on ii), enhancing the instruments used to obtain i). Many publications of category i) also have a contribution on ii). The issue is primarily one concerning i), but the work leads to developments of the instruments used. As mentioned in Section 1, the level of generality varies considerably for both i) and ii). In relation to i), it is common to develop hypotheses, models and theories. A hypothesis is considered an idea or proposition about the world, whereas a theory is an explanation or a model of aspects or features of the world (Cutler 2003). A theory is judged as more certain (the justification for its validity is stronger) than a hypothesis. A model is a representation of an aspect of the world. Developing such hypotheses, models and theories is conceptual and its contribution to the research is essential for accurately describing the research. When conducting work related to i), the empirical elements are often focused, for example, the data and results established through interviews and surveys. Using the logic in Section 3, also the conceptual elements are addressed.

The distinction between empirical and conceptual methods is not clear-cut, and many research methods are most accurately understood as a mixture. This would include methods for analyzing and generating meaning from empirical data as these methods alternate between the empirical data and the conceptual ideas. In this paper, we have categorized such data analysis methods as empirical, consistent with common terminology in research methods literature, but they could also be categorized as conceptual.

There are normative elements in all types of research as research is not value-free. When arguing for the suitability of a concept or method in risk analysis, the conclusion is deduced from conditions that to varying degrees are value-based. We should however require scientists to be as little as possible influenced by their religious and political convictions (Hansson and Aven 2014). Research that concludes that people should quit smoking, needs to base their conclusions on some specific norms and values, which of course could be contested.

6. Conclusion

This paper discusses research methods used in risk science. It argues that risk research can be viewed as a combination of empirical and conceptual research, with different emphasis depending on the purpose of the research. If the goal is to describe aspects of the world, the empirical part is the central one, but there will always be conceptual elements. Conversely, if the goal of the research is to enhance the instruments used to analyze and handle such aspects, the conceptual part is the central one. The level of empiricism would vary, but some elements would be present as scientific work builds on the current knowledge. Thus, when describing the risk research method used in a specific case, it is necessary to explain both the empirical and conceptual parts. Often the conceptual part – with its reasoning and argumentation – is undervalued as a contributor to the research and its findings.

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