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A framework for understanding risk based on the concepts of ontology and epistemology

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ABSTRACT

Two fundamental philosophical concepts of social science are ontology (idealism and realism), relating to what reality is, and epistemology (epistemological realism, epistemological idealism), relating to how one can obtain knowledge about that reality. These concepts are cornerstones in identifying, understanding, and describing core strategies in sociological theorizing (empiricism, substantialism, rationalism, and subjectivism). Similar philosophical concepts have been introduced and defined in risk science, to explain, assess and understand the risk concept. This paper studies and reconciles these two perspectives with the aim of obtaining new insights on how risks can be better understood, described, and communicated. Earlier work on this topic is extended by using contemporary risk science knowledge, as recently presented by the Society for Risk Analysis. The paper presents a framework for depicting the different ontological and epistemological stands in the risk domain. This framework can be useful for both theoretical and applied researchers studying risk.

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1. Introduction

Any science needs to clarify the meaning of key concepts. This paper focuses on philosophy, social sciences and risk science. For example, in social sciences it is essential to express what society is and, in risk science, what risk is. The issues relate to fundamental questions about what the nature of society and risk is, respectively. These are the *ontological* questions that metaphysics, a b ranch of philosophy, investigates. Ontology is concerned with the nature and relations of being, what are the states of the world. What society and risk are cannot be understood and studied without also considering knowledge about the world, about the society and risk. These considerations refer to epistemology, a branch of philosophy that examines the nature of knowledge, its presuppositions and foundation, its extent, justifications and validity (Audi 2003).

Different ontological and epistemological premises exist. For example, ontology is commonly seen as covering ontological idealism and ontological realism, and epistemology as covering epistemological idealism and realism (Stanford Encyclopedia of Philosophy 2021). The present paper aims at relating these generic premises to risk, by comparing and contrasting perspectives in social sciences (Johnson, Dandeker, and Ashworth 1987; Mouzelis 1991) and risk science (Aven, Renn, and Rosa 2011). To illustrate, think about the ontological premise of realism (Rosa

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1998). In social sciences, it expresses the notion that risk exists independently of our understanding of it (Rosa 1998). In risk science, different definitions of the nature of risk are presented. Some definitions meet this independence criterion, others do not (Aven, Renn, and Rosa 2011). There is also an issue regarding whether the discussion relates to the concept of risk and how it is measured or described. Risk may meet the criterion as a concept but not the measurements or characterizations of the magnitude of the risk. In the paper, we systematically review and discuss the relevant ontological and epistemological premises and the main strategies in sociological theorizing with respect to prevailing understandings of risk in social sciences and risk sciences. By identifying similarities and differences, we aim to gain new and improved insights on how to understand, describe and communicate risk. A framework is presented, providing an overview and structure, linking these categories, understandings and concepts.

The paper draws on and extends earlier studies on ontologies and epistemologies related to risk, particularly those of Rosa (1998, 2003), Aven, Renn, and Rosa (2011) and Solberg and Njå (2012). The paper aims at providing new insights by bridging knowledge from philosophy, risk science and social sciences (Johnson, Dandeker, and Ashworth 1987; Mouzelis 1991). Another key input to the discussion is recent foundational documents presented by the Society for Risk Analysis (SRA 2015, 2017), addressing basic understanding of risk and related concepts. A framework is presented for clarifying the different ontological and epistemological stands in relation to alternative perspectives on risk.

The main elements commonly used to define and understand risk include events (A), consequences (C), uncertainty (U), knowledge (K) and probability (P). In the paper, we relate these elements to the different ontology and epistemology categories referred to above. For example, if risk is seen as a combination of events, consequences and associated uncertainty, (A, C, U) (SRA 2015; Aven, Renn, and Rosa 2011), or if risk is basically seen as an event (Rosa 1998), how would we then classify risk using the different ontology and epistemology categories? How does time influence this discussion? The events and consequences relate to the future, but we may face risk now. Similarly, how would we classify the risk characterizations (judgments and measurements in risk assessments) using these categories? As mentioned above, discussing ontological and epistemological issues requires that we are clear on whether we talk about the concept of risk or its characterization (measurement, description). For the risk characterizations, epistemology is the main concern—with K and P playing key roles—whereas, for the concept of risk, both ontology and epistemology need to be discussed. Probability can be an epistemological tool but could also have an ontological status. There are different interpretations and uses of the probability concept, and it is essential for the current discussion to be precise regarding what we mean when referring to probability.

The paper is mainly about understanding risk, the risk concept and ways of measuring or describing the magnitude of this risk, in relation to questions about ontology and epistemology. In its turn, this understanding has implications for risk communication and risk handling. However, risk communication and risk handling issues, for example how people make or should make decision when faced with risk and uncertainties, are outside the scope of the present paper.

The paper is organized as follows. Section 2 presents the announced framework, integrating ontological and epistemological categories and risk perspectives. Readers are not expected to be experts on both fundamental philosophical concepts of social science and risk science, and basic theory has therefore been included on both these topics. The novelty and contribution of the paper lie in the integration, but the delineations and definitions of the ontological and epistemological categories and risk perspectives are critical for integrated analysis and for the understanding of the framework. Section 3 illustrates key features of the framework for COVID-19 risks. Section 4 discusses how the framework complements earlier work in the field, what new aspects it brings and what the benefits and limitations of the framework are. Finally, Section 5 provides some conclusions.

2. The framework

This section presents the framework classifying different perspectives on risk with respect to basic ontological and epistemological categories. A distinction is made between the risk as a concept and the risk characterization (description). It is essential to make this distinction as the ontological and epistemological categories could be different for the concept and the characterizations. Table 4 summarizes the results. The framework builds on two main pillars: a set of ontological and epistemological categories, and a set of risk perspectives. These categories and perspectives are presented and discussed in Sections 2.1 and 2.2, respectively.

2.1. Ontological and epistemological categories

In this section, we review some ontological and epistemological premises relevant to the coming discussion. These premises have their basis in philosophy, applied to a social science context. A key source is Johnson, Dandeker, and Ashworth's (1987) study, which provides a thorough discussion of the ontological and epistemological premises in social sciences, with a focus on sociological theorizing.

Tables 1 and 2 present the categories that will be used in this paper. It is to large extent based on Johnson, Dandeker, and Ashworth (1987), who present a fourfold typology for discussing strategies in sociological theorizing. This typology draws on both metaphysical (ontological) and epistemological (knowledge-related) dimensions. The major strategies are empiricism, subjectivism, substantialism and rationalism. Before describing the meaning of these strategies, we summarize the ontological and epistemological premises considered by Johnson, Dandeker, and Ashworth (1987).

The basic ontologies are idealism and realism. Ontological idealism refers to the notion that society is based on ideas, for instance, how humans understand and believe things to be, and how humans construct the reality as it is. Ontological realism implies that reality (social phenomena) has an existence that is independent of the human observer (Blaikie 2007). Johnson, Dandeker, and Ashworth (1987) uses the concept of ontological materialism that refers to that all facts, including the human mind and human history, are causally dependent on and reducible to physical processes or social structures, such as hierarchies and power relationships, which guide human behavior and action (Johnson, Dandeker, and Ashworth 1987; Mouzelis 1991). Ontological materialism can be seen as a variation of the ontological realism. In social sciences materialism is connected to Marxist tradition and theorizing of society. We have chosen to use the term ontological realism as it is more common than materialism when discussing the main ontologies—it is here understood as including materialism (Creaven 2001).

The two main knowledge-related premises are epistemological realism and epistemological idealism. According to epistemological realism, knowledge is gained through sense experiences,

Table 1. Fourfold typology of sociological theories (based on Johnson, Dandeker, and Ashworth 1987).

		Ontology	
		Ontological realism – There is a reality outside us	Ontological idealism – The reality is mind constructed
Epi stemology	Epistemological realism – Knowledge is gained through sense experiences	*Substantialism* and *Classical empiricism*	*Rationalism*
	Epistemological nominalism/idealism – Reality is made up of particular and unique things – Knowledge is gained through mental constructions	*Modern empiricism*	*Subjectivism*

Table 2. Ontologies and epistemologies of four social science strategies (partly based on Johnson, Dandeker, and Ashworth 1987).

Strategy	Ontology	Epistemology
Empiricism	Realist ontology: Reality exists outside us.	The only source of knowledge derives from sense experience (observations). Knowledge about the reality is gained via systematic observation, data gathering and the use of rigorous methods, including technical devices. Realism: classical empiricism sees the direct correspondence between the reality and observed things. Nominalism: the modern version of empiricism emphasizes the uniqueness of things and denies universalism.
Subjectivism	Idealist ontology: Reality consists of the meanings that people attribute to things and that they create in interaction with other people. Social reality is a human construction.	Idealism: Individuals' meanings and beliefs give knowledge about the reality.
Rationalism	Idealist ontology: Reality consists of an objective structure of ideas and belief systems, which constrain humans. Ideas and meanings are not attributes of individuals.	Knowledge is gained independently of sense experience. We need to find a logic, patterns or rationality that guide human thinking and rationality. Realist epistemology: society consists of thought and belief systems that act as an objective and constraining structure.
Substantialism	Realist (Materialist) ontology: Reality consists of social structures.	To gain knowledge, we need to approach and analyze economic and social structures which constrain human action, and social practices.

by direct observations of reality (Horwich 1982). Knowledge about an earthquake is obtained by observing this event.

Epistemological idealism is often represented as a counterpart to epistemological realism. It states that everything that we can *know* about the reality is held to be permeated by activities of the mind. Johnson, Dandeker, and Ashworth (1987) present nominalism as a counterpart to epistemological realism. Nominalism refers to the doctrine that universals, concepts, and generalizations in science are just summaries of particular observations. Research objects need to be treated as unique objects that are tied to a specific time and space (Waal de 1996).

There is broad agreement among scholars regarding the meaning of the concepts of ontology and epistemology. However, the relationship between ontology and epistemology is debated (Furlong and Marsh 2010). The common perspective is that ontology precedes epistemology, and they both guide methodological choices (Hay 2007). However, some scholars argue that the relationship is the opposite—epistemology precedes ontology (in the sense that ontology is 'grounded' in epistemology—ontology considerations rest upon epistemological priors that enable claims about what exist or not in the real world), others argue that ontology nor epistemology is prior to the other, but instead are to be seen as mutually and inextricably interrelated (Bates and Jenkins 2007).

Different terms are used to ontological and epistemological positions. In some studies, ontological positions like ontological realism and ontological idealism are named as 'objectivism' and 'constructivism', respectively, whereas epistemological positions like epistemological realism and nominalism/idealism are referred to as 'positivism' and 'interpretivism', respectively (Bryman 2001; Rosa 1998). Positivism is seen as applying natural science's methods to social sciences, whereas interpretivism emphasizes the need to interpret other's thoughts to understand reality (Spencer 2000).

The following strategies of social theories combine idealist or realist ontologies, and realist or nominalist/idealist epistemologies; see Tables 1 and 2.

Empiricism embraces the realist ontology, meaning that the reality consists of real observable things. Empiricism endorses the idea that sense experience, gained for instance via observing

the environment, is the source of all knowledge (Johnson, Dandeker, and Ashworth 1987; Pojman 2003; Blaikie 2007). We divide empiricism into two epistemological perspectives, as shown in Table 1. Classical empiricism represents epistemological realism; knowledge is gained directly from the reality through our senses and can be expressed in an objective language. The more modern version of empiricism represents epistemological nominalism: it emphasizes that reality is made up of particular and unique things. It does not accept universalism: that you can generalize from something unique and specific. What we observe changes over time and space and also depends on the social and cultural context. It is, for instance, difficult to draw general conclusions about epidemics by observing earlier ones, like the Spanish flu. However, epistemological nominalism also captures aspects of ontological idealism. Consider, for example, *social class* (upper class, working class, middle class, etc.), which does not exist as such—as a directly observable phenomenon—one needs to have a rationality (some criteria) to determine how particular observations can be attributed to the category.

For the empiricist strategy, the methods by which the knowledge is gathered and analyzed play a crucial role. There is a quest to develop suitable methods to avoid biases related to observations made by individuals. The validation of knowledge in the empiricist strategy is based on experience and rigorous application of methods. Nominalism, as an epistemological premise of empiricism, signifies that the observations from a reality are tied to a certain context and time.

Subjectivism is based on the idealist ontology, where reality consists of the meanings that people attribute to things and that they create in their interactions with other people through linguistic symbols. Reality is a human construction. Knowledge about the reality is obtained based on meanings. The validation of knowledge occurs by studying the views of individuals and the extent to which the theory or statement is compatible with the understanding of people regarding the same issue (Johnson, Dandeker, and Ashworth 1987; Mouzelis 1991).

Substantialism adopts a materialist view of reality. It stresses that physical things or social structures are more relevant than thought and consciousness (Mouzelis 1991). Substantialist theories emphasize social structures, such as social and economic positions, as well as human action, as overriding facts compared to ideas or meanings. Ideas—for example, farmers' pragmatic view of nature and city dwellers' romantic view of nature—are seen as manifestations of material relationships, e.g. how people are linked to nature through their work. The validity of a social theory or statement is tested by looking at the praxis, which, simplified, means human actions. If the praxis is in accordance with the theory, then the theory is seen as valid.

Rationalism acknowledges society as an objective and constraining structure of ideas and belief systems, affecting how we act. It emphasizes that meanings and ideas are not the attributes of individuals, as in subjectivism. Ideas are beyond individual consciousness (Johnson, Dandeker, and Ashworth 1987). Rationalism stresses reason as the fundamental base of knowledge (Blaikie 2007). The validation of knowledge occurs by looking at the logical consistency of the knowledge, such as social theory. Rationalists often create their views through two phases. First, they emphasize that the 'content of our concepts or knowledge outstrips the information the experience can offer'. 'Second, they construct accounts of how reason provides that additional information about the external world' (Stanford Encyclopedia of Philosophy 2021). Rationalism also means that one uses foundational knowledge to obtain new knowledge and 'truths' (Mouzelis 1991; Stanford Encyclopedia of Philosophy 2021).

The presented strategies are in tension with each other. For instance, subjectivists endorse the idea that reality is a social construction, whilst rationalists emphasize that meanings are not attributes of individuals and knowledge is gained independently of sense experience through reasoning. Empiricists argue that reason alone does not provide superior knowledge. For empiricists, observable facts and rigorous methods are key to strong knowledge. Substantialists emphasize the role of social structures and praxis shaping social reality.

In practice, all social theories need to resort to more than one strategy, as sticking to one strategy leads to challenges (Johnson, Dandeker, and Ashworth 1987). As an example, the rationalistic strategy emphasizing rationalization as a means to gain knowledge about the reality may recourse to an empiricist strategy, to test whether the logic also works in the empirical world. Similarly, an empiricist strategy emphasizing sense experiences often recourses to rationalism and acknowledges that reflective understanding is necessary to understand the reality (Stanford Encyclopedia of Philosophy 2021). The scientific method (also referred to as the 'hypothetico-deductive method') is based on a combination of empiricism and rationalism. It typically has the following steps (Wolfs 2009):

1. observations and descriptions of a phenomenon,
2. formulation of a hypothesis to explain the phenomenon, for example using a mathematical relationship,
3. use of the hypothesis to predict the existence of other phenomena or to predict the results of new observations, and
4. performance of experimental tests to verify or falsify the hypothesis.

In the philosophy of science, it is also common to refer to positivism and constructivism, see also Rosa (1998) and Alharahsheh and Pius (2020). Positivism corresponds in our study to classical empiricism or a mixture of classical empiricism and rationalism, whereas constructivism parallels the subjectivistic strategy. The Johnson, Dandeker, and Ashworth (1987) scheme, as reflected in Tables 1 and 2 and used in this paper, is somewhat more fine-grained than the positivism and constructivism categories. The scheme goes beyond these categories by adding the strategies of rationalism and substantialism that are not covered by positivism and constructivism. It allows for more refined discussions of the links between strategy and risk perspective.

2.2. Risk science perspectives

There are many perspectives on risk, the framework highlights four. These cover some main categories as shown by the analysis in Aven, Renn, and Rosa (2011) and Aven (2012). For the purpose of the present study, these four are considered sufficient. Table 3 presents the main message from this section.

The setup is as follows (SRA 2015). We consider an activity, for example the design or operation of a technical system, an investment, or life in a community, country or on the earth. The activity leads to some consequences C, with respect to something of value. These consequences cover the totality of states, events, barriers and outcomes. Alternatively, we can say that events A can occur, leading to consequences C. As an example, think about the event A as a fire in a building and C as the consequences in terms of fatalities given this fire. How to define the event is subject to discussion—a choice has to be made. An event A could alternatively be defined as for example a fire leading to at least one fatality. Guidance is provided by risk science and risk assessment practices how to choose the events. By defining events A of the type fire, the number of events is not too large—it is manageable—and it allows for studies of vulnerabilities and resilience given the occurrence of the event. For the purpose of the present work, the key is that an event is commonly introduced when conceptualizing and describing risk. Following SRA (2015), an event is understood as the occurrence or change of a particular set of circumstances such as a system failure, an earthquake, an explosion or an outbreak of a pandemic, or as a specified change in the state of the world/affairs.

The focus is on undesirable or negative consequences or outcomes, but the outcome of the activity could also be desirable or positive. The risk perspective 'A or C' is defined by the events

Table 3. Fundamental issues related to different risk perspectives.

Risk perspective issue	(C,P_f) or (A,C,P_f)	(C,P) or (A,C,P)	A or C	(C,U) or (A,C,U)
Risk as a concept always exists	No	Yes	Yes	Yes
Distinction between concept and its measurement/ description	Yes	No	Yes	Yes
Risk is claimed to exist objectively, independent of the assessor	Yes	No	Yes	Yes
The measurement or description of risk is based on the concepts defining risk	Yes	Yes	No	Yes
How uncertainty is reflected	Variation is reflected in the concept of risk. Uncertainties about P_f is described using statistical instruments (like confidence intervals) and subjective probabilities	Subjective probabilities are used to reflect uncertainties about events and consequences	Not an aspect of the concept risk, but uncertainty is described in risk assessments using probabilities and other tools	As a core feature of the concept of risk, this uncertainty is described in risk assessments using probabilities and strength of knowledge judgments

A (Rosa 1998, 2003) or the consequences C (IRGC 2005). Hence, the event 'getting cancer' is a risk according to this perspective (A) or 'getting cancer and dying' (C). The (C, U) and (A,C,U) perspective adds uncertainty U to the risk concept. Hence 'getting cancer' is not a risk, according to this perspective, but a possible or potential event that could occur, and this aspect of 'could occur' also needs to be included when defining risk. So, according to the (C,U) and (A,C,U) perspective, risk includes not only the events 'getting cancer' and 'dying' but also the uncertainty about whether you get cancer or die.

Following the $(C,P_f)/(A,C,P_f)$ and (C,P)/(A,C,P) perspectives, uncertainty is replaced by probability. In the former case, frequentist probabilities P_f form the basis, whereas, in the latter case, knowledge-based or subjective probabilities P are used. When risk is defined based on frequentist probabilities, it is assumed that an underlying true probability exists—and, hence, risk—reflecting variation of similar activities. This probability and risk are in general unknown and need to be estimated using data, modeling, expert judgments, etc. A frequentist probability of an event A is interpreted as the fraction of times the event A would occur if we could repeat the situation over and over again infinitely. Uncertainties about P_f is described using statistical instruments (like confidence intervals) and subjective (knowledge-based) probabilities. These probabilities P expresses the assessor's uncertainty or degree of belief; hence, there is no underlying true probability, nor a distinction between the concept of risk and how it is described or measured (SRA 2015, 2017; Lindley 2006; Aven, Renn, and Rosa 2011). Thus, this is the only risk perspective among these four principles, in which there is no distinction between the concept and its measurement (description). It is acknowledged that risk is subjective or inter-subjective. For the other three risk perspectives, the same applies to the associated risk measurements or descriptions, whereas the risk as concept can be argued to be independent of the assessor (Aven, Renn, and Rosa 2011).

Frequentist probabilities cannot be meaningfully defined for unique cases; for example, it does not make sense to talk about the frequentist probability of the global temperature increases by 1 degree in a future time period. The world cannot be meaningfully repeated. Hence the $(C,P_f)/(A,C,P_f)$ risk perspective is not defined for all risk situations.

The risk measurements or descriptions address the events, the consequences and uncertainties/probabilities. Hence, for the perspective 'A or C', the risk measurements or descriptions need to see beyond the concepts defining risk. To discuss how large the risk is, we cannot just consider A and C, we must also address the uncertainties. To measure or describe the uncertainties, subjective (knowledge-based) probabilities—precise or imprecise—are commonly used. In addition, recommendations are made to add judgments of the strength of the knowledge supporting these probability judgments (SRA 2017). The knowledge that the probabilities are based on, should always be presented. The concept of knowledge is debated, but in this paper, it refers to justified beliefs (SRA 2015), supported by data, information, tests, models, reasoning, etc.

2.3 The integration of risk perspectives and ontological and epistemological categories

Consider first the risk perspective (C,P_f) or (A,C,P_f). The risk concept is based on the idea of the existence of true underlying frequentist probabilities associated with the events and consequences A and C. As such, one can argue that the risk exists independently of our understanding of it; hence, it is labeled ontological realism. However, the construction of the frequentist probabilities requires some mental constructions and, therefore, a degree of rationalism. This construction is to varying degrees subjective; hence, subjectivism also needs to be included. In some cases, a strong level of agreement can be obtained on how to do this construction; inter-subjectivity is achieved.

In the risk characterization, risk is described (measured, estimated), and this characterization does not exist independently of the assessors but is obtained by mental knowledge processes. When it comes to epistemology, the risk characterization is based on some reasoning and depends on the assessor; hence, the categorization refers to rationalism and subjectivism. Data and information provide input to this description, and social structures may influence the way the data and information are collected, interpreted and analyzed (for example, on what is considered accepted perspectives and thinking on a topic such as climate change). Hence, in addition to rationalism and subjectivism, empiricism and substantialism also provide input to risk characterizations.

As an example, think about the risk of a nuclear meltdown associated with a nuclear plant, and, to simplify, let us consider risk defined by the frequentist probability p of such a meltdown. Then p is assumed to exist independently of the assessor, and, in the risk description, p is estimated using data, models and expert judgments. In theory, we can think ontological realism to categorize the risk, but the construction of p requires a mental construction; hence, aspects of rationalism apply. For the risk description, the estimate of p depends on the assessors, justifying the categorization of rationalism and subjectivism.

Now consider the second risk perspective category, (C,P) or (A,C,P). Here, the risk concept coincides with its description. From an ontological and epistemological point of view, the risk description is similar to that of the risk perspective (C,P_f) or (A,C,P_f), hence, covering rationalism and subjectivism and building on and acknowledging empiricism and substantialism. Returning to the nuclear meltdown example, there is no reference to a true underlying frequentist probability. Risk is defined and described by subjective (knowledge-based, judgmental) probabilities, which also means rationalism and subjectivism (with a basis in empiricism and substantialism).

For the third risk perspective, A and C, the risk concept refers to events and consequences, like nuclear meltdown, which exist independently of the assessor, as discussed in Section 1. Thus, we refer to ontological realism for the risk concept. For the risk characterization, we can argue, as for the previous two perspectives, that it covers descriptions and measurements of

Table 4. Risk perspectives from ontological and epistemological perspectives.

Risk perspective		Ontology	Epistemology
(C,P_f) or (A,C,P_f)	Risk concept	Ontological realism	Rationalism Subjectivism (inter-subjectivism) is an issue
	Risk characterization	Ontological idealism	Rationalism and subjectivism Based on acknowledging empiricism and substantialism
(C,P) or (A,C,P)	Risk concept	Ontological idealism	Rationalism and subjectivism Based on acknowledging empiricism and substantialism
	Risk characterization	Ontological idealism	Rationalism and subjectivism Based on acknowledging empiricism and substantialism
A or C	Risk concept	Ontological realism	Rationalism Subjectivism (inter-subjectivism) is an issue
	Risk characterization	Ontological idealism	Rationalism and subjectivism Based on acknowledging empiricism and substantialism
(C,U) or (A,C,U)	Risk concept	A and C: Ontological realism U: Ontological idealism	U: Rationalism (also about inter-subjectivism but not really an issue)
	Risk characterization	Ontological idealism	Rationalism and subjectivism Based on acknowledging empiricism and substantialism

uncertainties—for example using subjective probabilities—and, hence, is about rationalism and subjectivism (with a basis in empiricism and substantialism). In the nuclear example, the likelihood of meltdown could be described by subjective probabilities based on models of the plant and using relevant data and expert judgments.

Finally, we discuss the (C,U) or (A,C,U) risk perspective. For the risk concept's ontology issue, we need to separate A and C, on the one hand, and the uncertainties U, on the other. For A and C, the situation is similar to the risk perspective A and C analyzed above. For the uncertainties, there is an aspect of idealism, as well as rationalism—and subjectivism (inter-subjectivism)—as the uncertainty in relation to the concept of risk here refers to the idea that the future events and consequences are not known (see also Aven, Renn, and Rosa 2011). When it comes to the risk characterization, the reasoning is as above, particularly for the A and C perspective, as the characterizations cover potential events and consequences and assess uncertainties about these events and consequences, for example using subjective probabilities and judgments of the strength of the knowledge supporting these probabilities.

3. Illustration of the framework using the COVID-19 risk

This section illustrates the framework using a COVID-19 example, considering both the individual and societal levels. An (A,C,U) risk perspective is adopted. Suppose a consideration of risk is made mid-March 2020, looking into what will happen in the coming months and years.

Then, there is ontological realism explaining that risk exists independent of us. What exist independent of us are events and consequences, for example that a specific person gets COVID-19, that the person becomes an ICU (Intensive Care Unit) patient, the number of ICU patients in a country, the number of fatalities, etc. When uncertainty is included in the risk concept, there is an element of ontological idealism, our minds are involved in a different way, expressing that these quantities are not known to us. They are mind-constructed conclusions.

In March 2020, we may conduct risk assessments concerning what A and C will be. Risk is characterized. It is a mental construction, hence ontological idealism. As described in the

previous section, the risk characterizations are rooted in rationalism and subjectivism, and supported by empiricism and substantialism. Think about a risk characterization of the form of a 90% prediction interval [a,b], expressing that the number of deaths in the coming year will be within this interval with 90% probability. The probability is interpreted as a knowledge-based/subjective probability. Two intervals are presented, one based on societal shutdown and one without. To be concrete, the interval could be 100,000–200,000 in the former case, and 1–2 million in the latter. The knowledge supporting the assignments is judged as weak. The numbers are based on models developed representing the phenomena and processes (rationalism and substantialism), relevant data available (empiricism) and judgments made by the analysts (subjectivism).

Empiricism in the risk characterization of COVID-19 focuses on sense experiences and systematic collection of data regarding the specific events (such as infection rates) and their consequences (such as deaths). Empiricism adheres to a collection of adequate data and a coherent use of advanced methods to analyze the data to obtain a prudent risk characterization. (Modern) empiricism would take into account spatiotemporal factors, such as culture and specific time period. Rationalism supports the reasoning for expressing or describing the uncertainties, the probabilities and the strength of knowledge judgments, as well as the models supporting these judgments. Observational data are not available to meaningfully describe the prediction interval. Subjectivism emphasizes that risk characterizations represent subjective and inter-subjective judgments, meanings and beliefs. The prediction interval is a subjective or inter-subjective statement, not a fact independent of the assessor.

Substantialism pays attention to social structures and power structures, which may influence the risk characterizations. To illustrate, in most countries, national health institutions had a key role in framing the COVID-19 risk discussions. Epidemiologists and medical doctors dominated the risk communication, especially at the beginning of the pandemic. Broad societal reflections were given rather little attention. The substantialism perspective highlights the importance of this type of social structures and power structures, which could have strong effects on the risk characterizations.

A person's risk understanding is influenced by many factors, including expert judgments, media and their own risk assessments. This understanding should be distinguished from the person's risk perception, which could also include feelings and possible judgments about risk acceptability. The person's risk understanding could reflect that COVID-19 represents a very low risk for the person, yet the person may dislike the risk and feel stressed when for example going to the grocery store. The risk is perceived as high. The perception aspect adds a different dimension to the risk compared to the risk perspective and risk understanding. The way decision makers and health experts view, and approach risk could strongly affect how individuals understand and perceive risk. An illustrative example of this in relation to COVID-19 is Sweden where the leading State Epidemiologist, Anders Tegnell, strongly influenced the public understanding and perception of the corona virus risk. At the early stage of the pandemic, his message was that the risk was low. He did not refer to or founded his judgments based on any formal risk perspective, and it can be questioned if a stronger risk basis would have led to an improved information basis for the public, see discussion in Glette-Iversen, Seif, and Aven (2022). This example from Sweden also illustrates the micro-macro linkages (Alexander et al. 1987); here mainly about how micro (individual) level risk understanding can influence macro (institutional and societal) level risk understanding and handling.

4. Discussion

Rosa (1998) presents two main strategies in theorizing risk: positivistic and constructivist paradigms and expresses the hope that the subject of debate in the risk field would change from

what is risk to what is our knowledge about risk. The present work highlights four different strategies (empiricism, realism, rationalism and subjectivism) and argues for the need to focus on both the ontology of risk as a concept and the epistemology, i.e. how we can get knowledge about risk. We argue for the need to make a clear separation between risk as a concept and characterizations or measurement of risk.

Aven, Renn, and Rosa (2011) discuss ontological aspects of the concept of risk, based on common ways of defining risk similar to those discussed in Tables 3 and 4. The present paper extends the analysis of Aven, Renn, and Rosa (2011), by providing a metatheoretical basis which links the understanding of risk to the strategies in sociological theorizing, empiricism, realism, rationalism and subjectivism. The paper allows researchers in the risk domain to be able to explain their approach and methodological choices based on ontological and epistemological insights and assumptions. Being aware of the metatheoretical basis enables a better justification and explanation of the approach and methodological choices. It also contributes to revealing strengths and weaknesses of the research.

As briefly mentioned in Section 2, we need more than one strategy to assesses and understand risk. A classical empiricist-oriented researcher can claim that rationalism is not an adequate basis for understanding the risk, because logic alone cannot provide superior knowledge about the risk. A rationalist-oriented researcher, on the other hand, can criticize classical empiricism for lacking a proper logic or rationality that guides the information gathering. There are different attempts to reconcile the different perspectives, and risk assessments in practice always combine different strategies. For instance, the empiricist and rationalist strategies are combined, so that rationalism can provide hypotheses and rationality, on the basis of which the collection of data is planned and conducted. Similarly, it is possible to check the rationalism's logic, based on the empiricism and gathered data.

Subjectivist-oriented researchers would emphasize the need to look at the individual and inter-subjective construction of meanings because, without understanding the meanings that humans attribute to risks, the understanding of the risk characterization would be poor. Substantialist-oriented researchers, on the other hand, would criticize subjectivism for neglecting the social structures behind the individual or inter-subjective construction of meanings. Without seeing the meaning construction in connection with the material basis, such as social hierarchies and power structures, the understanding of meaning attributed to risks would be biased.

Substantialist-oriented researchers would criticize rationalism for purifying and detaching logic and rationality from social structures. As discussed in Section 3, social structures, such as hierarchies, and power structures, including political decision-makers and their priorities, may influence which aspects of risk are focused on. Similarly, substantialist-orientated researchers would criticize empiricism for lacking understanding of relevant structures which influence the empirical data gathering, and thus would indicate a naïve understanding of society and related risks.

The modern version of empiricism in social sciences is based on nominalism, stressing that all social phenomena are unique and spatiotemporal. It can be discussed whether this spatiotemporality is given enough attention in risk characterizations. Often a rather static risk picture is presented.

5. Conclusions

Risk science, with its basis in risk assessment, communication and management, plays important roles in society. The assessment, communication and management depend on the understanding of the risk concept and its characterization. The literature shows that there are many different ideas and perspectives defining and describing risk. Extensive work has been conducted, trying

to clarify the foundational basis of the risk field, but there remains considerable confusion on many issues, for example on the understanding of the concept of risk. The present paper aims at contributing to improving this basis by matching key philosophical concepts of ontology and epistemology, sociological theorizing strategies and risk science perspectives on better understanding and characterizing risk. Ontology refers to an understanding of reality and epistemology to how one can obtain knowledge about that reality.

A framework has been developed for analyzing and understanding the different risk perspectives, using these ontological and epistemological considerations and the fourfold typology in sociological theorizing (empiricism, rationalism, subjectivism, and substantialism). The framework allows us to clarify the similarities and differences of the different risk perspectives. The framework is illustrated by using the COVID-19 risk as a case.

This paper is conceptual, and an effort has been made to maintain a balance between adequately describing the concepts and presenting simple structures and logic. Some issues and topics have been thoroughly discussed, others only briefly or not at all. One topic that is not covered in depth is the question about the interrelationship between ontologies and epistemologies (Scotland 2012). It is an interesting topic from a philosophical point of view but not considered essential for the discussion in the present paper.

We have focused on the risk concept. From our analysis, similar insights can be derived for related terms such as vulnerability, resilience and safety (Aven and Thekdi 2022). To illustrate, vulnerability can be seen as conditional risk given an event or a risk source. This means, for example, that, for the (A,C,U) risk perspective, vulnerability takes the form (C,U|A), where '|' indicates given the event A. The discussion about the risk (A,C,U) in the paper can more or less directly be transformed to the vulnerability (C,U|A).

The discussion in the paper shows the importance of making a distinction between the risk concept and risk characterization. Much of the confusion observed in practice concerning risk can be traced back to the concept of risk being mixed with its measurement or characterization. Clarity on the risk fundamentals—what risk really means and expresses—is important for both risk research and the use of risk science in practice, in understanding risk, communicating risk and handling risk. Both risk research and risk science use are often not precise on the risk perspective. However, clarity on risk understanding and the risk fundamentals is difficult, if not impossible, without clarity of the risk perspective.

Disclosure statement

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