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Uncertainty decomposed: understanding levels of contingency to enable effective decision-making[1]

Sebastian L. Grüner

RheinMain University of Applied Sciences, Wiesbaden, Germany
https://orcid.org/0009-0002-3285-103X

Abstract

Background: Uncertainty is a common challenge in managerial decision-making, especially when it comes to predicting future states, establishing cause-effect relationships, and having knowledge about relevant variables. However, it is difficult to deliberately address different types of uncertainty by applying specific decision-making strategies and hence enable reduction of uncertainty due to overlapping definitions and conflicting operationalization of the uncertainty construct.

Purpose: The paper aims to delineate types of uncertainty along their epistemological configurations in terms of specific knowledge contexts to enable choices of suitable strategies for specific decision-making situations.

Study design/methodology/approach: A literature review revises and discusses concepts of (un)certainty based on (im)perfect information and objectively/subjectively available assemblages of knowledge.

Findings/conclusions: The paper provides a framework that encompasses and differentiates configurations of available information and knowledge applicable to decision-making situations. In order to achieve construct clarity and to free the original concept of uncertainty from conflicting definitions and heterogeneous operationalizations, the umbrella term contingency is introduced. It encompasses all states of (im)perfect information and variations in their epistemological configurations. Finally, the presented epistemological framework delineates levels of contingency along specific qualities of available information. The identified and discussed levels of contingency are certainty, risk, uncertainty in the narrow sense (i.n.s.), complexity, ambiguity/equivocality, and isotropy/radical uncertainty. The delineated levels of contingency help to tailor decision-making situation to specific epistemological configurations and hence may serve as a starting point for concluding and developing appropriate strategies to reduce contingency.

Limitations/future research: A holistic understanding how to deal with and solve contingency requires further research focusing on aligning levels of contingency with strategies for decision-making (algorithms, causation, effectuation, bricolage, improvisation, trial & error) by taking types of knowledge (structural, procedural, conceptual) and contextual factors (e. g. time, [origin of] resources) into account.

Keywords

uncertainty, contingency, decision-making, strategic management, knowledge, epistemology

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Introduction

The notion of uncertainty has continually been a catalyst for theory-building in metaphysical sciences such as philosophy, as well as in non-metaphysical sciences including formal, or social sciences such as mathematics, sociology, or economics. Dealing with uncertainty has led to epistemological question about what is knowledge (Aristotle & Sachs, 2002; Descartes, 1996; Townsend, Hunt, McMullen & Sarasvathy, 2018), what are types of knowledge (Polanyi, 1966), how to accumulate knowledge (e. g. Hume, 2021) and how to apply knowledge in order to make decisions or predictions (Tversky & Kahneman, 1992). In line with that, research on decision-making under uncertainty has a long tradition among management scholars. Avenues have pointed out a rational perspective that assumes perfect information available to agents (Ariely, 2010; Kahneman & Tversky, 1979; Tversky & Kahneman, 1981). Others have rather focused on dealing with situational constraints (e. g. scarcity of resources and time) (Hmieleski & Corbett, 2006; Shepherd, Williams & Patzelt, 2015) or heuristic strategies (e. g. *effectuation*) (Dew, Read, Sarasvathy & Wiltbank, 2009; Sarasvathy, 2001) to tackle imperfect information.

Knowledge has been identified as a critical variable in dealing with and conceptualizing uncertainty. Agents' knowledge and experience influence how they make decisions and how they perceive and exploit business opportunities (Shepherd et al., 2015). It favors the identification of future states and outcomes in general (Shepherd & Patzelt, 2018) and in special fields (e. g. identifying financing opportunities) Seghers, Manigart & Vanacker, 2012). Knowledge represents "structures that people use to make assessments, judgments or decisions involving opportunity evaluation and venture creation and growth" (Mitchell et al., 2002, p. 97) on individual level.

At the organizational level, knowledge, as a bundle of intangible resources, is considered a sustainable and effective tool for gaining and maintaining competitive advantages (Wiklund & Shepherd, 2003). It is declared to be the basis of competencies, whereas competencies mean the ability to establish and repeat knowledge-based regular (not random) processes to achieve future market action and maintenance (Freiling, 2008). In summary, knowledge and knowledge-generating routines or strategies help deal with uncertainty.

Activatability and availability of knowledge in decision-making situations determine the choice of decision heuristics. Current research in the field investigates how strategists address incomplete knowledge problems (Rindova & Courtney, 2020), which typically incorporate microfoundations of decision-making such as which information is available, what are current/future states of development, by which variables are those states defined and how are they interrelated? "When should managers and entrepreneurs forecast and plan, and when should they adopt a more dynamic, adaptive strategy?" ask Packard and Clark (2020, p. 766) and conclude depending on the context and the extend of uncertainty in the given situation. However, the conceptualization of uncertainty remains inconsistent (Berglund, Bousfiha & Mansoori, 2020; Ramoglou, 2021). Widely debated levels and types of uncertainty are neither clearly distinct nor selectively defined, which makes it difficult to conclude specific (practical) and generalizable solutions (e. g. decision-making strategies) from specific contexts and extend of uncertainty. In addition to neglecting the role of individual actors, the current debate has not yet produced a concept that incorporates a unified understanding of recognized types of uncertainty (Sniazhko, 2019).

The motivation for this paper lies in the importance of decision-making for organizations in general and for entrepreneurial ventures in particular, which are confronted with liabilities of smallness, newness etc.. 50 % of new ventures fail within 5 years, 75% within the 10 years (U.S. Bureau of Labor Statistics, 2023). This leads to the question if failure rates are caused by exogenous reasons (e. g. market dynamics) or endogenous reasons (e. g. poor resource base, poor strategy) and hence how far failure is influenced by decision-making strategies or the agent's competences in handling decision-making situations. Similar challenges affect established organizations operating and striving toward survival in vivid and fast-growing markets. Despite major companies' failures (e. g. Lehman Brothers in 2008 or Enron in 2007) is effective decision-making also crucial and existential to successful companies such as Alphabet, who meanwhile have long lists of suspended products and services (Ogden, n.d.)? The paper can contribute to the aspects named above by attributing qualities of information to decision-making situations and hence enabling effective decision-making by applying appropriate strategies (e. g. to create additional information) .

By reviewing the literature and existing concepts, the paper aims to delineate types of uncertainty to provide a holistic framework of contingency defined by specific epistemological configurations for particular levels of contingency. First, existing uncertainty constructs are reviewed and briefly discussed. Second, the idea of *contingency* is introduced to free the concept of uncertainty from conflicting definitions and heterogeneous operationalization. Third, types and levels of contingency are discussed. Therefore, initially the concept of *certainty* is explored first in order to delineate further levels of contingency. The concept of *uncertainty in the broader sense (i.b.s.)* remains of central importance and will therefore be treated and dissected in more detail. Levels of contingency (*certainty, risk, uncertainty in the narrow sense [i.n.s.]*, *complexity*, *ambiguity/equivocality*, *isotropy/radical uncertainty*) become concluded and presented successively. Forth, the discussed levels of contingency are aggregated to a contingency framework based on epistemological configurations and fifth, implications for further research avenues towards strategies to reduce contingency enabling effective decision-making are concluded.

1. Revision of existing uncertainty constructs

Undoubtedly, the concept of uncertainty has been used and applied in countless academic papers. However, the development of holistic frameworks for the understanding and differentiation of uncertainty levels has been limited. This section is an overview of the major contributions to the topic. The seminal literature is reviewed and the identified constructs are briefly discussed. They are organized chronologically and substantively (Table 1).

Knight (1964) distinguishes between *risk* and *uncertainty* (*Knightian uncertainty*). Both dimensions depend on given knowledge about outcomes and probabilities. Risk is present in decision-making situations where the outcomes can be estimated stochastically as the consequences of taking certain actions. For example, the relatively new field of extreme event attribution estimates that the risk of heavy rainfall recurring in the 2020s in Kyushu, Japan, increased by 15% due to climate change (Otto, 2023). Risk situations involve precise knowledge of outcomes and associated probabilities. Decision-making situations characterized by uncertainty also involve knowledge of eventual outcomes resulting from actions taken, but lack precise stochastic estimation. This is especially true when the number of known/comparable cases is too small to derive patterns and/or when the interdependencies and interactions of the variables involved are too high and nonlinear. In such situations, Knight concludes that actions based on judgmental decision-making because probabilistic estimates of the consequences of acting are not available or attainable. An archetypal case is that of an entrepreneur who is faced with uncertainty in deciding how to allocate, activate, and utilize resources in order to enter and succeed in an unknown market (Audretsch & Belitski, 2021). Because the consequences of actions and future states are not objectively probabilistically distinguishable, action in situations of Knightian uncertainty requires intuition, experience, and gut feeling.

In contrast to Knight, who distinguishes between risk and uncertainty according to rational and objective probabilities, Savage (1972) emphasizes a more subjective point of view. He understands actions to be driven by expected utility maximization and based on probabilities, although estimates may be subjectively (incorrect) and subsequently updated (Packard, Clark & Klein, 2017). His formulated *Savage Axioms* include individual risk preferences. They are limited to cases where sets of options and outcomes/future states are closed, which means that complete knowledge is objectively present.

Shubik (1954) focuses on information (and its costs) in his discussion of uncertainty. Agents faced with a closed set of outcomes and knowledge of the relationships among relevant variables find themselves in situations of *certainty* (e. g., custom-made products with all necessary resources available and processes known). Knowing a closed set of outcomes, but being faced with probabilities regarding the relationships between relevant variables, is considered a situation of risk (e. g., custom-made products with either not all necessary resources available yet, or not all processes yet known). When the set of outcomes is closed, but both the set of relevant variables and the probabilities of their relationships are not closed, *indeterminacy* occurs. It is exemplified by firms in competitive markets where there is incomplete information about the action-reaction relationships among competitors. Finally, *ignorance* of information is identified by Shubik. Ignorance ranges from individual unwillingness to generate knowledge (e. g. due to high costs) to general impossibility (e. g. due to epistemological constraints). Thus, both a subjective and an objective perspective are considered in the level of ignorance. Further research on the subjective perspective is being conducted by Sharot and Sunstein (2020) who ask the question "How do people decide what they want to know?"

Ellsberg (1961) confirms the Savage Axioms (Savage, 1972) by showing that decision-making is highly subjective: Agents may deselect one of two options that are objectively equal, but select options that are unequal. However, Ellsberg also challenges Savage's Axioms by showing that risk is dominantly preferred over what he calls uncertainty or ambiguity. Ellsberg substantiates his finding by experimenting with 2 urns. One contains a fixed number of balls in certain colors. The first contains a known proportion (50 red, 50 black). The second urn has an unknown proportion of black and red balls. Participants are asked first to choose the color they would bet on and then to choose the urn from which the ball will be drawn. As a result, most participants choose the first urn with the known 50/50 proportion. However, drawings from the second urn have the same probability, given that any color from the initial set can be included. Ellsberg's approach is strictly formal while working with a closed set of outcomes (2 colors of balls). It leaves the set of relevant variables and the probabilities of their relationships subjectively open to the agents. Although the experiment actually represents a situation of risk, it points to the possibility that information may not only be hidden but actually non-existent.

In the tradition of systems theory thinking, Thompson (2017) views uncertainty from the subjective perspective of organizations. Organizations are understood as semi-open systems, which develop their identity and operations based on self-selected information from their environment. They deal with issues that they can control, but they have incomplete information about them. *Incompleteness* requires awareness of what is missing. Furthermore, they deal with contingent issues (*contingency*) that they cannot yet control because they are not yet relevant to or recognized by the organization. In order to achieve and maintain internal efficiency but structural openness, Thompson suggests the implementation of autonomous organizational subdivisions. This enables subsystems to develop (their own) complexity and increases the organization´s capacity to deal with incomplete information. According to Thompson, incompleteness and contingency are subjective and different for each organization. Both depend on specific internal and external variables and lead to contingent future states. Subjective contingency then means that for organizations, some things are not yet known and have not yet been decided, and that this has to be resolved in a distinctive way by individual organizational capabilities (e. g., through acceptance and preparation for contingency). Thompson (2017, p. 24) summarizes: "some of the factors involved in organizational action become constraints, for some meaningful period of time they are not variables but fixed conditions to which the organization must adapt. Some of the factors become contingencies, which may or may not vary, but are not subject to arbitrary control by the organization. Organizational rationality therefore is some result of (a) constraints which the organization must face, (b) contingencies which the organization must meet, and (c) variables which the organization can control."

Milliken (1987) presents an approach that focuses not on probabilities but on the absence of certain types of information. She distinguishes between three types of uncertainty: *state*, *response*, and *effect uncertainty*. State uncertainty reflects the inability of agents to predict developments in an organization's environment. This is due to the dynamism and complexity of the environment. Response uncertainty occurs when agents have no known specific actions to address state uncertainty. Finally, effect uncertainty is present when the consequences of actions are not known to the agents or cannot be predicted. Milliken leaves open the question of whether there are information gaps in an objective sense or whether they exist only on a subjective level. Her approach mainly tackles operational capabilities aiming at fulfilling certain organizational tasks (including dealing with lack of knowledge).

Spender (1989) adds Shubik's (1954) distinction. Besides risk and indeterminacy, he identifies the uncertainty states of *incompleteness*, *irrelevance* and *incommensurability*. Incompleteness means, a little more precise than Thompson (2017), situations of decision-making in which information can be known, but it is not gathered. Indeterminacy remains defined by situations in which there is a closed set of outcomes but there is no information about their probabilities (e.g., the reactions of a firm's competitors). Up to that point, outcomes of actions and causal relationships can be clearly identified by collecting enough information. However, not for the level of *irrelevance*. It represents decision-making situations where the outcomes and causal relationships of relevant variables cannot be arbitrarily determined. A set of outcomes may be given, but the formation of the outcomes is not clear, nor are the causal relationships of the formative elements (e.g., one outcome may have several causes). Finally, cases of *incommensurability* identified by Spender convey some information and relationships between formative elements lie beyond the epistemological boundary. Some things may be unknowable to agents or to society as a whole in a subjective and objective sense.

Building on that objectivity/subjectivity perspective , Dosi and Egidi (1991) relabel and combine existing levels of uncertainty. For them, *weak substantive uncertainty* is similar to risk according to Knight (1964), represented by a) a closed set of outcomes, b) the knowability of probability distributions, but c) the lack of information about "the occurrence of a particular event […] in principle representable as a random drawing by 'nature'" (Dosi & Egidi, 1991, p. 148). Conversely, *strong substantive uncertainty* presupposes an open set of outcomes, not allowing inference to probability distributions. This type of uncertainty is pretty similar to Shubik's (1954) and Shackle´s (2010) concept of ignorance or Spender´s (1989) concept of incommensurability. Finally, in their conceptualization, Dosi and Egidi (1991, p. 146) also consider subjective perspectives of agents by identifying *procedural uncertainty* as "competence gap in problem-solving" to deal with substantive uncertainty.

Closely related to Dosi and Egidi (1991), Campos, Neves, & Campello de Souza, (2007) distinguish between resolvable uncertainty (Type B) and insolvable uncertainty (Type A). Solvability means that additional empirical effort, such as research, will generate knowledge about relevant variables, relationships, and thus probabilities. Type A uncertainty is characterized by more or less aleatoric elements that cannot (yet) be resolved by further research.

Dequech (2011) adds ambiguity and *fundamental* uncertainty to the idea of Dosi and Egidi (1991). Ambiguity is defined in the meaning of Ellsberg (1961), which is that outcomes are closed, information about probabilities is missing but could be known. This limits the understanding of ambiguity to a subjective problem. By fundamental uncertainty (also procedural uncertainty) Dequech (2011, p. 623) means unknowability. It is present when sets of outcomes and options are "not predetermined or knowable ex ante, regardless of what people do, as the future is yet to be created". The focus on processes and knowledge makes Dequech's approach compatible with research on epistemological configurations, or types of knowledge from Barr, Doyle, Clifford, Leo, & Dubeau. (2003), Berge and Hezewijk (1999), Nonaka and Takeuchi (1995), Nonaka and Toyama (2007), Sanchez (2005).

Recent research on the dimensions of uncertainty expands on the findings of earlier studies by consolidating them and bringing them together. In addition to further detailing epistemology (knowledge-related dimensions), they also focus more on incorporating subjective and objective perceptions of uncertainty (Angus, Packard & Clark, 2023). Packard et al. (2017) distinguish earlier discussed states of risk and ambiguity from *environmental*, *creative*, and *absolute uncertainty*. In line with Knight (1964), risk remains understood by the current level of knowledge about the outcomes and the probability of occurrence. Ambiguity does the same but considers the subjectivity/objectivity distinction emphasized by Ellsberg (1961). It must be borne in mind that the Ellsberg experiment objectively represents risk although this does not necessarily reflect the subjective perspective leading to irrational decisions. Creative uncertainty is represented by knowledge of outcomes but not of underlying causes or processes. This way, creative uncertainty is technically solvable if enough experience and/ or data would be available. Environmental uncertainty is defined similar to Milliken´s (1987) state uncertainty reflecting decision situations where individual outcomes of actions are not/cannot (yet) be fully known due to dynamism and complexity of the environment. Last but not least, absolute uncertainty which is present when neither outcomes nor underlying causes or processes are known. The classification of Packard et al. (2017) represents a relatively new classification for types of uncertainty that include earlier discussed concepts aligning them in a holistic framework.

A matrix to classify uncertainty according to the existing knowledge about sets of outcomes (possibilities) and options (probabilities) is presented by Stirling (2010), Oehmen and Kwakkel (2020). A high level of both is referred to as risk. Low knowledge of options but high knowledge of outcomes occurs in situations of uncertainty. The reverse configuration represents ambiguity. Finally, low knowledge in both categories represents ignorance. The more open-ended (low knowledge) the set of outcomes, relevant variables, and the causal relationships between them, the higher the level of uncertainty. Apart from their genuinely handy distinction, the authors do not offer a holistic classification of knowledge beyond known probabilities, or, to put it differently, what "high" and "low" actually means.

Building on earlier research in the area of uncertainty, Dequech (2011) presents a holistic framework that aims to include various different types of uncertainty. He defines weak uncertainty (also substantive uncertainty) including both risk according to Knight (1964) (knowledge of objective probabilities) and uncertainty according to Savage (1972) (no information/knowledge of objective probabilities but given subjective, not quantifiable probabilities). Dequech also adopts the idea of procedural uncertainty from of Dosi and Egidi (1991) as an overarching concept that can be ascribed not only to the objective non-existence of information, but also to the subjective non-existence to agents when available information is not processed or used. However, procedural uncertainty becomes unfolded now when differentiating between risk, ambiguity and fundamental uncertainty. A good example of procedural uncertainty in the situation of risk would be chess. The game contains a closed set of outcomes, variables, relations, and probabilities, but mostly imperfect move execution due to players' cognitive limitations. Dequech's understanding of ambiguity is for the most part similar to that of Ellsberg (1961) but different from of Stirling (2010). For Stirling, ambiguity occurs when knowledge of probabilities of known outcomes (set of option) are complete but knowledge of set of outcomes and future states are incomplete. Dequech and Ellsberg understand ambiguity inversely, with knowledge of outcomes and future states complete (red/black ball urn experiment) but probabilities of subjectively known outcomes incomplete (urn 2 with unknown distribution). From an objective point of view, the Ellsberg experiment is only risky, but from a subjective point of view, the second urn seems more ambiguous to the participants. Dequech refers to ambiguity as being characterized by information that is hidden rather than non-existent; just like Camerer and Weber (1992, p. 330) state "ambiguity is uncertainty about probability, created by missing information that is relevant and could be known." In order to take into account situations in which information cannot yet be known, Dequech defines the sphere of fundamental uncertainty. This state is represented by situations in which future knowledge does not yet exist. It cannot be confirmed ex ante without hindsight bias, nor can its time of emergence be predicted. Fundamental uncertainty contains information that has not yet been declared to be missing because agents are unaware of its existence.

Packard et al. (2017) emphasize the (in)completeness of information about consequences of actions (set of options) and outcomes/future states (set of outcomes), building on Dequech´s (2011) approach. The set of outcomes reflects existing knowledge/information about all possible future states. The set of options reflects existing knowledge/information about courses of action to achieve the respective outcomes/future states. When both sets are closed, with full information about outcomes and options, situations are called risky or ambiguous. This understanding of ambiguity, where information is only hidden to agents but objectively exists, is consistent with that of Ellsberg (1961). In situations with a closed set of outcomes and an open set of options, *creative uncertainty* exists. This means that there is full information/knowledge about outcomes and future states. However, there is limited knowledge about their probabilities of occurrence. Examples of creative uncertainty are mainly found at the subjective level. They occur when the outcome of a task is known, but the processes and actions are not. Situations with open outcomes but closed sets of options are called *environmental uncertainty*. These situations contain complexity because the system and environment interact. Agents make decisions based on information about their environment (e.g., competitors). At the same time, their actions affect the environment. This cybernetic effect of feedback generates imperfect information about outcomes and future states (open set of outcomes). However, sets of options can be closed because they can be constantly updated depending on information about the environment. Ultimately, when both the sets options and outcomes are open, absolute uncertainty exists. Packard et al. (2017) illustrate this state from the perspective of entrepreneurs with a radically disruptive business idea because they do not yet know what their outcomes may be, and thus they cannot predict the causal relationships between the actions they take.

Townsend, Hunt, McMullen & Sarasvathy. (2018) differentiate somewhat more clearly and with a clarified understanding from previous scholars between uncertainty, complexity, ambiguity and something he calls *equivocality*. Uncertainty (like risk) is understood as a typical knowledge problem and can be solved by collecting more information, e.g. through repetition. *Complexity* is introduced as a distinct level for uncertainty taking into account that the number of relevant variables and their interactions is high. Complexity leads to similar outcomes as a result of different actions, or similar actions leading to different, indeterminable outcomes. In situations of complexity, causal relationships are nonlinear and cause-effect relationships are not clear. Other than for earlier scholars, in the understanding of Townsend et al. (2018), ambiguity is present in an objectively vague decision environment. Fractured relationships between outcomes and options may be present, but they are incompletely known, and there are questions about the rules that should be applied in particular situations. Finally, there is equivocality in situations where more information is not sufficient for resolution. Information is so scarce that there is no objective, universal answer. Society must compete to make sense of the situation. Townsend et al. (2018) mention the climate change debate for an example of equivocality.

The effects of subjective uncertainty and external unpredictability on entrepreneurial actions are further explored in a recent study Angus et al. (2023). The authors follow the understanding of Packard et al. (2017), which implicitly assumes that open and closed sets of options and outcomes determine the actions taken. They conclude that situations of uncertainty have a closed set of outcomes but an open set of options. In contrast, situations of complexity and unpredictability have open sets of outcomes and a more or less closed set of options. Their research represents the actual status quo of the discipline.

The above-mentioned conceptualizations of uncertainty and are summarized in

Table 1. The table shows only those constructs that were actually discussed by the authors. Some gaps remain due to neglect. Some constructs overlap. Some constructs are defined and/or labeled differently by different authors although conceptual similarities. In order to contribute to more construct clarity around the term uncertainty, the paper takes this as a starting point.

Table 1 Existing conceptualizations of uncertainty levels

Author(s)					
Knight (1964)	Risk	Uncertainty			
Savage (1972)	Risk	Uncertainty			
Shubik (1954)	Risk		Indeterminacy		
	Ignorance				
Ellsberg (1961)	Risk		Ambiguity		
Thompson (2017)		Incompleteness		Contingency	
Milliken (1987)				State uncertainty	
				Effect uncertainty	
				Response uncertainty	
Spender (1989)		Incompleteness	Indeterminacy	Irrelevance	Incommensurability
Dosi and Egidi (1991)	Weak substantive uncertainty			Strong substantive uncertainty	
	Weak and strong procedural uncertainty				
Campos et al. (2007)	Type B uncertainty			Type A uncertainty	
Stirling (2010), Oehmen and Kwakkel (2020)	Risk	Uncertainty		Ambiguity	Ignorance
Dequech (2011)	Weak substantive uncertainty			Strong substantive uncertainty	
	Weak and strong procedural uncertainty				
	Risk	Ambiguity		Fundamental uncertainty	
Packard et al. (2017)	Risk/Ambiguity		Creative uncertainty	Environmental uncertainty	Absolute uncertainty
Townsend et al. (2018)	Uncertainty		Complexity	Ambiguity	Equivocality
Angus et al. (2023)	Subjective uncertainty		External unpredictability		

Source: Adapted from Packard et al. (2017) and extended by author

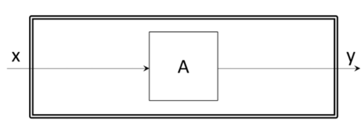
2. Reframing types of uncertainty as levels of contingency

To promote construct clarity and avoid terminological confusion, the umbrella term uncertainty in the broader sense (i.b.s) is renamed *contingency*. According to Spinoza (2003), refers contingency to a specific openness of possibilities and options. Contingent situations are characterized by chance, which means that something may or may not happen, that something may or may not be true. Levels of contingency encompass different degrees of what is known and what can be known about specific decision situations. Situations of (almost) perfect information characterize lower levels of contingency, while higher levels are characterized by decreasing information quality (in terms of amount and clarity). Contingency may replace the umbrella term uncertainty (i.b.s.) to allow for the coverage of different types of uncertainty and beyond.

The levels of contingency are outlined in the following chapter. They depend on specific epistemological configurations represented by the availability of specific knowledge dimensions. These include i) knowledge about WHAT are possible future states/outcomes of action and the related relevant variables, ii) knowledge about HOW LIKELY possible future states/outcomes of action and the influence of relevant variables are, iii) knowledge about WHY future states/outcomes of action will occur as a result of the causal relationship and distinctiveness of outcome-related variables, and finally, based on this, vi) knowledge about WHEN future states/outcomes of action will occur because of knowledge about sequence of outcome-related variables. The levels of contingency discussed increase with the lack of information. The identified and concluded levels are certainty, risk, uncertainty (i.n.s.), complexity, ambiguity/ equivocality, and isotropy/radical uncertainty.

Certainty

Certainty represents the lowest level of contingency and marks the starting point of the epistemological contingency framework. Certainty is ascribed to situations that are characterized as trivial because they have only one (reasonable) condition or state. In trivial situations, a given, specific input always produces a specific, predictable output (just like an equation with one variable). Triviality assumes a clear causal relationship between input and output (Foerster, 1985). In contrast, non-trivial situations can have at least two conditions or states, e.g. , these situations can produce one or another output for the same input, or they can produce different outputs for a given input (Foerster & Pörksen, 2023). **Figure 1** illustrates this distinction.



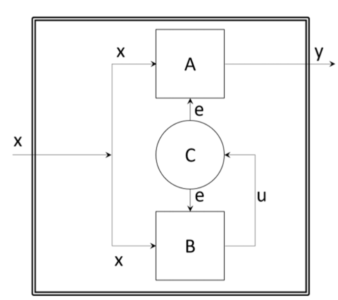


Figure 1 Situations of certainty (left) and situations of higher levels of contingency (right) exemplified by trivial and non-trivial machines
Source: Depiction based on Foerster, 2011, pp. 357–359

In situations of certainty, agents have knowledge of possible outcomes of actions/future states and their probabilities (Laux, Gillenkirch & Schenk-Mathes, 2014). In the case of sequences of events (variables), agents are familiar with consequences (sequence of outcome-related variables) and eventual outcomes/future states. For example, a traffic light for car traffic will turn green in a fixed and known time after it turns red. The pedestrian light will turn red after a certain number of seconds, which may indicate to the agent that it is time to shift into first gear of the car. Knowledge of the regularities of processes, sequences, causalities, and the differentiability of their intermediate events (variables) enables agents to be certain about the eventual outcomes of activities and actions. The same applies to situations in which a traffic light is turned off. Agents who are experienced drivers will most likely not wait for the light to turn green. They can clearly determine what alternative courses of action are available in known situations, and what eventual outcomes of actions follow from the states of the situation and their choices. The expected value of all future events is one, and all alternatives to a choice are "certain" alternatives. Situations of triviality are situations of low contingency and thus situations of certainty.

Risk

Formal sciences, engineering, and the insurance industry define risk as a stochastic and calculable quantity that is aggregated in the form of an expectation value. Insurance industry concludes expectation values of possible outcomes and future states as results from the product of the expected amount of damage/loss (or benefit/gain) and the probability that a future state will occur (Krohn & Krücken, 1993). Such a definition presupposes the quantifiability of the variables and intermediate states involved, which is typically achieved by stochastic or empirical methods based on large numbers of cases or iterations. Insurance companies can quantify risks and contract costs if they know the number of potential policyholders, the frequency of insured events, and the amount of damage. This can also include individual risks for specific contracts (e.g., insured damage by martens in addition to partial coverage), where the risk becomes the target variable of a mathematical calculation (Laux et al., 2014).

In contrast to the formal sciences, social sciences such as business administration are faced with the challenge that variables for risk calculation are often not or only incompletely quantifiable. In many cases, they are even unknown. Against the backdrop of bounded rationality, social science prefers to deal with the (non-)existence of information in the context of risk. This does not necessarily exclude proximate calculations ("[...] risk is most commonly conceived as reflecting variations in the distribution of eventual outcomes" (March & Shapira, 1987, p. 1404)), but makes the application of the term less dependent on quantitative dimensions ("[and] is embedded, of course, in the larger idea of choice as affected by the expected return on an alternative" (March & Shapira, 1987, p. 1404)). Thus, the concept of risk operationalized in social sciences is not strictly formal allowing to include the option of experience-based probabilities (educated guesses) and hence incomplete (because partially impossible) calculations.

For the development of an epistemological, contingency-based decision-making framework, the question arises as to the extent to which the concept of risk should be held in multiple (formal and/or social science) perspectives. In terms of distinctiveness, it seems less appropriate to build on two perspectives. In addition, the social science perspective of risk includes epistemological configurations of knowledge that are equally (or even more) applicable to uncertainty (i.n.s.) (see chapter on uncertainty). This suggests an operationalization of risk more along the lines of a formal concept, according to Savage (1972). According to that, a situation is said to be risky if all possible outcomes of actions/future states and relevant variables as well as their probabilities of occurrence are known. However, risk may involve incomplete knowledge of the causal relationships between all outcome-related variables and thus limited knowledge of when future states will occur. Put differently, although agents may a) know what can happen (possible outcomes/future states) and b) be able to state the probability of each possible outcome, they c) do not know with certainty when a future state will occur because d) they lack information about the causal relationship of all outcome-related variables. A typical example for that is flipping a coin. Outcomes are known (heads, tails), probability is known (50/50), the sequence of outcome-related variables (flipping, dropping, bouncing around) is known, but the outcome is not specifically determinable (physics behind the outcome) because of the inability to control the underlying causalities/relationship of outcome-related variables that lead to the outcome (heads or tails). Moreover, risky situations are also characterized by the prerequisite of being repeatable. Only the repetition of a situation (e.g., flipping a coin over and over again) with stable inputs, a limited number of variables, and subsequent output states allows the calculation of probabilities for the outcome (e.g. , ~ 50/50 out of 1000 attempts). This is an empirical challenge, especially for more complex situations, because the estimates of the probabilities often depend on the number of repetitions, which is determined by the number of variables involved. The larger the number of variables and output states, the larger the number of iterations required.

Uncertainty

"Uncertainty must be taken in a sense radically distinct from the familiar notion of risk, from which it has never been properly separated", notes

Knight (1964, p. 19). The distinction is drawn along the availability of quantifiable information. Decisions whose consequences (outcomes of actions/future states) are based on objectively known probabilities of occurrence and that can be calculated with the help of repetition or cumulative data collections are ascribed to be risky. On the other hand, *uncertainty (i.b.s)* in situations means that probabilities are not fully measurable or calculable in an empirical, formal sense. While risk can be reduced by a priori calculation or probabilistic estimation, uncertainty can only be managed by judgment and experience. Consequently, unlike risk, uncertainty is not insurable (Knight, 1964).

Knightian uncertainty serves as a result of this distinction and marks an expedient recourse to the construct of uncertainty in entrepreneurship and management literature. Because "[...] uncertainty is prevalent in business and other social situations, it is pervasive in entrepreneurial settings[...]" (Sorenson & Stuart, 2008, p. 530) and thus forms the starting point for the application of decision-making strategies such as effectuation in managerial decision-making (Sarasvathy & Kotha, 2001). Nevertheless, management research operationalizes the construct of uncertainty inconsistently, not generally as Knight understands it, and sometimes imprecisely. Essentially, the definitional scope of uncertainty (i.b.s.) ranges from ignorance of information, to lack of specific information, to the impossibility of having information and data (Packard et al., 2017; Ramoglou, 2021). Such variance in understanding the structure points to authors who equate uncertainty with *isotropy*. For them, there is perfect formal calculability on the one hand, and perfectly incalculable, unpredictable situations on the other. Definitions cover aspects such as that "environmental issues are, by their nature uncertain; the future is unknowable, and the framing of environmental issues occurs in a future context" (York & Venkataraman, 2010, 252f.). Or uncertainty defined as "[...] situation in which the missing information is yet to be created [...]" (Kuechle, Boulu-Reshef, & Carr, 2016, p. 46), which refers to the impossibility of recognizing future outcomes and much less being able to take them into account. The present paper adopts such a perspective and, at the appropriate point introduces a more distinct and precise construct of isotropy (see the chapter on Isotropy) by detaching the state from uncertainty (i.b.s).

Knight (1964, p. 265) also understands uncertainty in a similar way to isotropy, but less radically, implicitly stating that uncertainty is an objective problem that can only be addressed by society as a whole: "We must notice also the development of science and of the technique of social organization. Greater ability to forecast the future and greater power to control the course of events manifestly reduce uncertainty, and of still greater importance is the status of the various devices noted in the last chapter for reducing uncertainty by consolidation." While such a definition includes isotropic states in the sense of not knowing or not being able to foresee (akin to e.g. *unknowability* according to Ramoglou, 2021), it also points to a partial possibility of controlling, treating, or managing uncertainty through the collection of data and information. The problem with the Knightian understanding of uncertainty remains that it leaves a very broad epistemological spectrum open next to the formalist concept of risk. On the one hand, there are decision situations and outcomes that can be calculated, and on the other, there are decision situations and outcomes/future states that cannot even be predicted. Presumably, there must be something in between, because neither are all everyday decisions based on probabilistic calculations, nor are they made at random.

In the face of such challenges, later authors only partially adhere to Knight's strictly probabilistic distinction. They understand uncertainty not as linked to the general availability of information and data, but as determined by the possibilities of generating them. Uncertainty is seen not so much as objectively radical in the sense of the inability to know, but rather as a consequence of the inability or impossibility to accurately determine the outcomes of future decision states, e.g. because of a poor understanding of causal relationships between outcome-related variables (Downey & Slocum, 1975). Such a moderate understanding of uncertainty is primarily based on the assumption that some relationships between variables and outcomes are not yet or cannot be formally explored or manifested probabilistically.

Thus, March (1994) proposes a more nuanced understanding of uncertainty. He distinguishes between uncertainty, radical uncertainty, and Knightian uncertainty, which are often used synonymously. His distinction is based on a moderate definition of uncertainty and is different from the ones named above. Knightian uncertainty is more likely to represent the contingency level of ambiguity according to Oehmen and Kwakkel (2020), Townsend et al. (2018) and Stirling (2010). Although ambiguity is to some extent related to uncertainty in the moderate sense, it is also different in that ambiguity is based on a general lack of information. Uncertainty, however, is based on a temporarily limited understanding of what's known. Hence, *uncertainty in the narrow sense (i.n.s.)* may here be based on the assumption "[...] there is a real world that is imperfectly understood" (March, 1994, p. 178).

Questions about the objects of inquiry in the context of uncertainty can reflect the distinction between the moderate concept of uncertainty, ambiguity (Knightian uncertainty), and isotropy (radical uncertainty). Is there uncertainty in the environment? Are agents uncertain? Or are both of them uncertain? Isotropy/radical uncertainty and, to some extent, ambiguity (Knightian uncertainty) assume that uncertainty originates outside of the agent. This type of uncertainty, also known as Type A uncertainty, is characterized by stochastic variability of the environment (Campos et al., 2007), probabilities, outcomes, and relationships that cannot be identified or predicted in advance (Miller, 2012). Future states and outcomes of actions are incompletely known or not known at all, the probabilities of their occurrence are not calculable or calculable only to a limited extent, and the relationship between outcome-related variables is not yet fully understood. As a result, it remains highly uncertain what will come next (sequence of outcome-related variables) (Hoffman & Hammonds, 1994). Thus, in a planned way, e.g., through deliberate experimentation, perfect Type A uncertainty is considered irreducible. But there are also decision situations with partially available information, except for what is not yet known, that can be used to initiate processes of uncertainty reduction.

In addition, there is Type B uncertainty. It is caused by the agent's subjective inability to process available information. Type B uncertainty is similar to epistemic uncertainty and arises from a lack of knowledge, from scientific ignorance, or simply from non-observability (Campos et al., 2007).[2] Type B uncertainty is typically residual uncertainties that occur in educated guesses that are based on the opinions of experts or on logical-deductive methods of cognition. They are therefore not necessarily intractable. They are (theoretically) reducible through the expansion of systemic processing capacities (larger numbers of cases, more sensitive measurement methods, deliberate learning, improvement of indicators, investment of time and resources in experiments), since an approximation to complete information in a situation (even if not quantifiable) prevails or is attainable. In practice, however, clear causal relationships or sequences of outcome-related variables can only be probabilistically validated to a limited extent.

Distinguishing between Type A and Type B uncertainty then allows for different ways of relating the two types to each other. When Type A uncertainty is present, Type B uncertainty is also present. This is because agents cannot subjectively incorporate more information than is objectively available. The presence and perception of Type B uncertainty means that information about variables, regularities, and causalities is available but not (yet) reducible to certainty or risk. The hierarchy of uncertainty (i.b.s.) represented by the major uncertainty types A and B is shown in **Figure 2**. The contingency level of risk, as described earlier, is also subsumed under certainty.

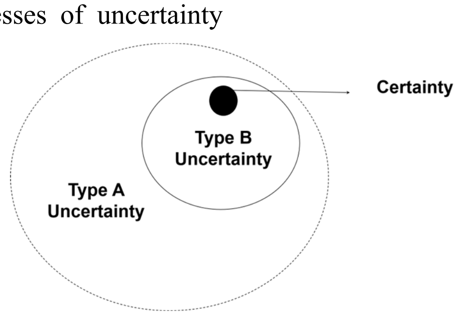


Figure 2 Relationships between types of uncertainty (i.b.s.)
Source: the author's own depiction

[2] Other authors distinguish between *primary uncertainty* and *secondary uncertainty* (Sutcliffe and Zaheer (1998), *aleatory uncertainty and epistemic uncertainty* (Packard, Bylund & Clark, 2021); Packard and Clark (2020)) or *weak* and *strong substantive uncertainty* (Dequech (2011); Dosi and Egidi (1991)), which are equivalent to Type A and Type B uncertainty.

Figure 3 shows the assumptions developed so far for different levels of contingency between uncertainty (i.b.s.). In addition to isotropy/radical uncertainty, which is assigned to Type A, and the subdivision of Type B uncertainty into uncertainty (i.n.s.) and complexity (see next chapter), ambiguity/equivocality (Knightian uncertainty) can be understood as an intersection of the two types. Type A uncertainty describes an objective lack of information. Type B uncertainty describes a subjective lack of ability or capacity to deal with the available information. Uncertainty (i.n.s.) differs from the formalistic concept of risk in its probabilistic limitations, since predictions about future states cannot (yet) be calculated. Nevertheless, experience-based and experience-supported predictions of future outcomes are possible in decision situations of uncertainty (i.n.s.). The chosen understanding of uncertainty (i.n.s.) thus fills a part of the space between radical uncertainty and calculable risk.

Uncertainty (i.n.s.) is similar to the concept of risk used in the social sciences. It allows for recourse to experience in estimating future outcomes. Theoretically, if agents can identify and manage all relevant variables, interrelationships, probabilities of occurrence, and sequences of outcome-related variables, such decision situations can be reduced from uncertainty (i.n.s.) to risk (formally) or even certainty. In practice, however, such endeavors are limited by the lack of time, the scarcity of resources, and the multiplicity of variables, including their interrelationships.

However, under uncertainty (i.n.s.), well-informed agents can make relatively reliable predictions. Either by applying experience-based, subjectively collected *a posteriori* probabilities, which serve as *a priori* probabilities for estimating future outcomes, or by applying and abstracting historical data to similar decision-making situations. Thus, the management of uncertainty (i.n.s.) largely depends on the ability of agents to make reliable, though not fully probabilistic, predictions by activating, applying, and linking existing information. This way, the concept is similar to what Arend (2022) calls *subjective uncertainty* and to what Spender (1989) refers as incompleteness to. Uncertainty (i.n.s.) is present when possible outcomes of actions and variables, including their characteristics, are known, but the causal relationships, sequence and probabilities of the outcomes are not yet fully probabilistically derived, or cannot be fully probabilistically derived.

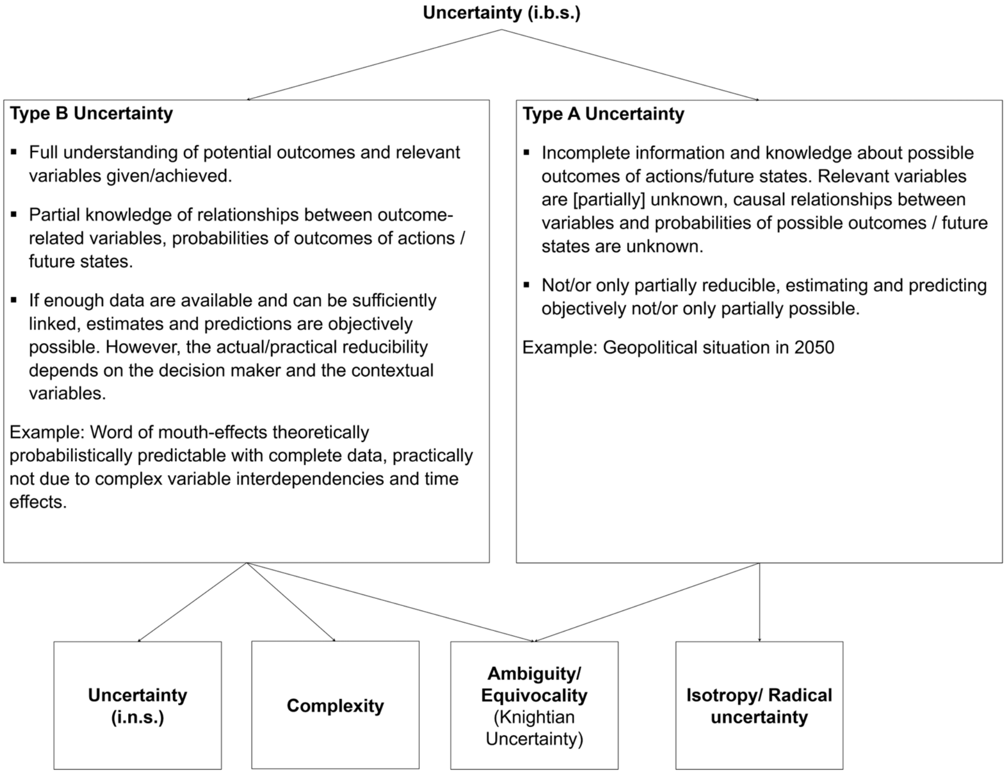


Figure 3 Ontology of major uncertainty types and contingency level differentiation
Source: the author's own depiction

Complexity

The *complexity* of knowledge structures in systems and organizations has a long tradition in cybernetic research. This, of course, has implications for management research if the management of complexity in dynamic environments becomes a special capability (Teece, 2007, 2012). Individual perceptions of complexity, among other things, significantly influence the application of decision strategies such as causation or effectuation to execute decisions (Mathiaszyk, 2017). Complexity has two main origins: *detail* and *dynamic complexity* (Townsend et al., 2018). Detail complexity represents a formal understanding and refers to the number of considered variables. Dynamic complexity arises from the possible interactions and interdependencies of the variables that are involved. The more variables and the more dependencies, the higher the degree of complexity.

A concept closely related to complexity is *emergence*. Emergence is a social, psychological, or physical phenomenon and ordering concept referring to a change in condition with new properties (for example, the whole is more than the sum of its parts). Complex systems do not behave linearly, but have the property of being able to form new structures based on how their elements interact.

Thus, a specific property of emergence is that it is not possible to infer an observed phenomenon directly from the properties of the underlying variables. The non-linearity of complex systems has come into particular focus as the success factors of organizations do not seem to follow a linear distribution, but rather an exponential one (success multiplies according to the Matthew effect)
Crawford, Aguinis, Lichtenstein, Davidsson, P., & McKelvey, 2015). Attribution difficulties arise when agents face complexity. They are challenged to compete in a complex environment because, on the one hand, they must identify relevant factors and variables that may influence their actions and, on the other hand, know and estimate the interactions and outcomes of these variables. Complexity is therefore generally considered as the "[...] heterogeneity and range of factors that have to be taken into account [...]" (Clarysse, Brunee, & Wright, 2011, p. 140) as well as "[...] the number of opportunity contingencies that must (be) addressed successfully" (Davis, Eisenhardt & Bingham, 2009, p. 420).

Complexity means that possible outcomes of actions/future states and variables are or can be known to agents (WHAT), in accordance with the introduced epistemological dimensions for classifying levels of contingency. Ambiguity would exist if outcomes of actions/future states or variables were beyond knowledge. Complexity arises from the number of variables involved, how they interact, and emergent dependencies. Sequences (WHEN) and causal relationships (WHY) between variables are partially but not completely clear to agents. Different interactions may have similar outcomes. As a result, formal probabilities for outcomes can hardly be inferred, not least because of the often small number of empirically measurable and comparable cases (HOW LIKELY). Complexity, however, remains a problem of emergence, not of fulfillment (according to Lorenz, 1975). It can be solved by identifying, selecting, and understanding relationships between relevant variables. To cope with external complexity (Crawford et al., 2015), agents need to increase internal complexity. Put differently, complexity can only be solved by complexity (Ashby, 1956; Beer, 1994).

Ambiguity/equivocality

In addition to complexity, *ambiguity* plays an important role in management research as well as for studying decision-making in business and organizational theory (Townsend et al., 2018, p. 671). Some authors understand ambiguity as a decision-making environment in which agents know the possible outcomes of their actions/future states, but it is not possible for them to specify the corresponding probabilities (Holm, Opper & Nee, 2013). Others explain ambiguity as a "[...] problem of interpretation because it results from a lack of understanding and/or consensus regarding the applicability of available knowledge" Rindova, V., Ferrier, W. J., & Wiltbank, 2010, p. 1477). Both of these perspectives limit ambiguity to a subjective problem of knowledge. On the other hand, ambiguity is understood as synonymous with isotropy/radical uncertainty (Fox & Tversky, 1995), which would mark ambiguity as an objective knowledge problem.

In the following, ambiguity is going to be treated as a bipartite concept, similar to the concept of *external unpredictability* by Arend (2022). It contains both objective and subjective limits of knowledge. That is, ambiguity is characterized by epistemological elements that are subjectively not yet known and epistemological elements that are objectively unknown (yet) and thus subjectively cannot be known.

Difficulties in predicting outcomes of repeated identical behavioral experiments led Ellsberg (1961) to conclude that ambiguity, along with uncertainty and risk, must be a distinct problematic category within decision theory. Ambiguity depends on the amount, type, reliability, and clarity of available information as well as agents' confidence in inferring outcome probabilities. Ambiguity thus takes into account what is also known in scientific discourse as the impossibility of making sense. In certain scenarios, agents are not able to distinguish signals from the noise in their environment (Weick, 1995) and are unable to translate an observed process or variable into a rational system (Townsend et al., 2018). Ambiguity then encompasses a decision environment "[...] in which alternative states are hazily defined or in which they have multiple meanings" as well as where "a 'real' world may itself be [...] a product of social construction" (March, 1994, p. 179). This is a reflection of the fact that in an ambiguous situation, although some information is available, there is always also an as yet unmarked space of no information.

Ambiguity is also considered to be similar to *equivocality*. By definition, equivocality arises from the existence of multiple meanings or interpretations of an object (Daft & Macintosh, 1981). Consequently, equivocality cannot be solved by more information because "the key problem in an equivocal situation is not that the real world is imperfectly understood and that additional information will render it understandable; instead, the problem is that additional information may not actually resolve misunderstandings" (Frishammar , Florén & Wincent, 2 011, p. 553). Ambiguous/equivocal situations do not have objectively clear answers (Townsend et al., 2018) and can only be resolved "through shared observations and discussion until a common grammar and course of action can be agreed upon" (Daft & Weick, 1984, p. 291). Or as Arend (2022, p. 5858) puts it: "Such problems are not only complex – because they involve interdependencies and unknowns – but are also non-optimizable."

The boundary between ambiguity/equivocality, complexity and isotropy/radical uncertainty is drawn along the lines of objectively available knowledge. Decision situations characterized by ambiguity/equivocality are to be placed between the major uncertainty types A and B defined by Campos et al. (2007). Ambiguity/equivocality exists when possible outcomes of actions/future states and outcome-related variables are not fully known because they cannot yet be fully known. Next to not knowing relevant variables, this is due to indifference to the relevance of known variables, their probabilities of appearing, sequences and causal relations (Davis et al., 2009; Ellsberg, 1961). Ambiguity differs from uncertainty (i.n.s.) in that the former is based not only on incomplete knowledge of causal relationships between means and ends, but primarily on the impossibility of predicting possible outcomes/future states. This is because relevant variables are not fully known. Their properties/roles are not yet distinguishable. (Garud & van de Ven, 1992).

Isotropy/radical uncertainty

Finally, the contingency level of *isotropy/radical uncertainty* will also be described, although it has already been referred to in the decomposition of the uncertainty (i.b.s.) construct earlier in this paper. Isotropy/radical uncertainty applies to decision situations in which outcome-related variables and their interrelationships are still completely unknown or undetermined in society (objectively). Similar to situations of incommensurability (Spender, 1989) and absolute uncertainty (Packard et al., 2017), isotropy/radical uncertainty applies to epistemological entities that are neither present nor can be predicted (Schneider, 1997). Outcomes of actions/future states in situations of isotropy/radical uncertainty are random and cannot be predicted based on current knowledge. The same is true for the probabilities of their occurrence. This is because outcome-related variables, causal relations and sequence of relevant variables are not yet perceived and processed by society. Outcomes of actions/future states in situations of isotropy/radical uncertainty are usually single events, from which knowledge about interrelationships etc. can only become generated retrospectively (sensemaking). Thus, the present paper supports Ramoglou's (2021) distinction between Knightian uncertainty and unknowability, understanding the former as similar to ambiguity/equivocality and the latter as similar to isotropy/radical uncertainty.

Isotropy cannot be resolved by intentional system-immanent emergence. This would require knowledge of a certain number of variables, dependencies, and correlations as a starting point for a goal definition (e.g., through research). Instead, isotropy/radical uncertainty is based on the fact that "[...] that in decisions and actions involving uncertain future consequences it is not always clear ex ante which pieces of information are worth paying attention to and which not" (Sarasvathy, 2008, p. 69). The resolution of isotropy/radical uncertainty is only possible through evolutionary leaps (fulgurations). In practice, the handling of isotropy/radical uncertainty[3] can be observed in terms of partnership heuristics in effectuation. *Crazy quilt* relies on flexible, arbitrary partnerships to achieve indeterminate sensemaking. Agents interact with partners who are close to them, known to them, willing to collaborate, and technically available. The purpose of engaging in partnerships is open-ended, not predefined, and emerges as participants interact. These kinds of activities are used to deliberately encourage contingency, to give unexpected outcomes and serendipity a chance. Rather than being overwhelmed by or resigned to a priori incomplete information, the challenge then becomes one of managing (and investigating) contingent situations quite effectively (Griffin & Grote, 2020). Similar to complexity, isotropy/radical uncertainty can only be countered by isotropy/radical uncertainty (Townsend et al., 2018). Random solutions must be generated for random decision situations. Indeterminate outcomes may then be the starting point for structured knowledge generation/experimentation.

3. Aggregated epistemological contingency framework

Error! Reference source not found. summarizes the discussed levels of contingency. The identified levels differ according to the epistemological configuration whether there is knowledge of possible outcomes of actions/future states and relevant variables (WHAT), knowledge of their probabilities (HOW LIKELY), knowledge of the sequence of outcome-relevant variables (WHEN), and knowledge of the causal relationship of outcome-relevant variables/the distinctiveness of all variables (WHY). The spectrum of the epistemological contingency framework is bounded on the left by the contingency levels of certainty and risk. Situations of certainty are represented by given knowledge about possible outcomes of actions/future states and relevant variables, including the probabilities of their sequences and how the variables are related to each other. Causal relationships are unambiguous. Outcomes are predictable and insurable. Risk is different from certainty because knowledge of causal relationships is incomplete and therefore immediate outcomes of actions/future states cannot be fully predicted.

Uncertainty (i.n.s.) and complexity both imply that certain predictions based on experience are possible, but that these are not yet fully revealed in the context of the variations of the variables involved. Possible outcomes of actions/future states and outcome-related variables are largely known. However, it is not yet empirically possible to fully trace causal relationships and effects of all variables beyond doubt or to prove them in a probabilistic sense. Complexity is further exacerbated by the need to account for too many variables with unknown causal relationships. Situations in which identical inputs generate different outputs, or different inputs generate identical outputs can be described as complex.

Ambiguity/equivocality represents a level of contingency in which there is more or less a lack of information. Compared to uncertainty (i.n.s.) and complexity, where there is imperfect knowledge about causal relationships between variables and outcomes, ambiguity occurs when agents do not fully know which outcomes of actions/future states can occur or what relevance which variables have within causal relationships. The fact that parts of the outcome-related knowledge have not yet been encountered is a major challenge in reducing this level of contingency. Agents can only work with incomplete causal relationships because they do not know what is missing. Consequently "[...] no certain answers exist and perhaps the right questions have yet to be formulated" Daft, Lengel & Trevino, 1987, p. 359).

The far-right pole of the epistemological contingency framework is isotropy/radical uncertainty. It is characterized not only by incomplete knowledge about possible outcomes of actions/future states and relevant variables, but also by incomplete knowledge about of their existence. Outcomes have no dominant probability, everything is equally possible (or not) (chaos), and beyond an existing "lack of clarity" for agents, "it is difficult to interpret or distinguish between possibilities" (Davis et al., 2009, p. 424).

[3] Some would say hoping for serendipity.

Table 2 Epistemological contingency framework: Increasing levels of contingency (from left to right) depending on available knowledge qualities

Level of (un)certainty/contingency → Criterion ↓	Certainty	Risk	Uncertainty (i.n.s)	Complexity	Ambiguity/Equivocality	Isotropy/Radical Uncertainty
WHAT? Complete knowledge of all outcomes of actions/future states and relevant variables	Given	Given	Given	Given	Incomplete	Missing
HOW LIKELY? Complete knowledge of probabilities of all outcomes of actions/future states and relevant variables	Given	Given	Incomplete	Incomplete	Missing	Missing
WHY? Complete knowledge of distinctiveness and causal relationships (of/between relevant variables)	Given	Incomplete	Incomplete	Incomplete	Missing	Missing
WHEN? Complete knowledge of sequence of relevant variables causing distinct outcomes	Given	Incomplete	Incomplete	Missing	Missing	Missing
Objective/subjective insurability	Given	Given	Potentially yes (, but depending on the possibility of empirical validation, a sufficient N of repetitions or based on educated guesses)	Potentially yes (, but depending on the possibility of empirical validation, a sufficient N of repetitions or based on educated guesses)	Missing	Missing
Example	e.g. "Death and taxes"	e.g. flipping a coin	e.g. competing in a pitch with an unknown N of competitors	e.g. development of United States Declaration of Independence in 1787	e.g. consequences of artificial intelligence	e.g. fortuity, development and rise of Facebook, discovery of ultraviolet light, Higgs-Boson
Major types of certainty and uncertainty (i.b.s.)	Certainty		Type B		Type A (depending on level of isotropy)	Type A

Source: own compilation

Discussion and conclusion

In order to enable the selection of appropriate strategies for specific decision-making situations, this paper aims to delineate types of uncertainty along their epistemological configurations in relation to specific knowledge contexts. In order to provide a framework that includes differences within uncertainty (i.b.s.), the terms certainty and uncertainty are first discussed. They are decomposed into distinguishable configurations of epistemological elements (knowledge). The distinction is conceptually related to Townsend et al. (2018) but extends their approach by including all conceivable levels of contingency and differing between them according a tailored set of knowledge entities. The paper is also related to Packard et al. (2017), who postulate open and closed sets of options and outcomes. These are signified by the presence (closed)/absence (open) of knowledge about all possible future states (outcomes) and the presence (closed)/absence (open) of knowledge about courses of action to achieve the corresponding outcomes/future states (options). Although the presented paper adopts the basic idea of existence/absence of knowledge regarding outcomes and options, it carves out the need for extending and clarifying the discussion about uncertainty.

The paper introduces contingency as an alternative umbrella term to avoid multiple meanings of uncertainty and to achieve construct clarity. Based on a literature review reflecting the main conceptualizations of uncertainty, it is concluded that knowledge and different epistemological configurations determine the levels of contingency. Some configurations of contingency require going beyond Packard et al. 's (2017) concept by also including aspects such as formal probabilities, clarity in terms of cause-effect relationships and finally the differentiation between subjective and objective knowledge. Therefore, the paper includes and refers to further concepts developed by Angus et al. (2023) (subjective uncertainty, external unpredictability), Townsend et al. (2018) (uncertainty, complexity, ambiguity, equivocality), Oehmen and Kwakkel (2020) (risk, uncertainty, ambiguity, ignorance), Campos et al. (2007) (type B and type A uncertainty), Spender (1989) (incompleteness, indeterminacy, irrelevance, incommensurability), Thompson (2017) (incompleteness, contingency), Ellsberg (1961) (ambiguity), Savage (1972) (risk, uncertainty), and, of course, Knight (1964) (risk, uncertainty) to conclude a framework that covers the varying presence and absence of different knowledge. It is assumed that agents may have complete or incomplete knowledge about all possible outcomes of actions/future states and relevant variables (WHAT), their probability of occurrence (HOW LIKELY), the causal relationships among relevant variables (WHY), and their sequence (WHEN). Levels of contingency vary depending on the extent to which each variable is present. The identified levels of contingency are developed and discussed, and summarized in form of an epistemological contingency framework. It covers states ranging from complete information to unknowability. These states are named as certainty, risk, uncertainty in the narrow sense (i.n.s.), complexity, ambiguity/equivocality, and isotropy/radical uncertainty.

The framework can serve as a prerequisite (e.g., configuration, presence, and availability of knowledge) for effective decision-making by enabling the selection of an appropriate decision strategy. Decision theory has developed several strategic approaches to deal with contingency in order to enable and ground decision-making (Chandler, DeTienne, McKelvie & Mumford, 2011; Dew, Read, Sarasvathy & Wiltbank, 2009; Sarasvathy, 2001). That is, causation focuses “on the predictable aspects of an uncertain future” while effectuation focuses “on the controllable aspects of an unpredictable future” (Sarasvathy, 2001, p. 251). These approaches have been the subject of intense debate due to the seemingly arbitrary and overlapping assumptions about their configuration (Arend, Sarooghi & Burkemper, 2015; Grégoire & Cherchem, 2020; Read, Sarasvathy, Dew & Wiltbank, 2016). This paper contributes to construct-clarity of uncertainty by complementing the discussion on the configuration of Knightian uncertainty, unknowability (Ramoglou, 2021) as well as (objective) unpredictability and (subjective) uncertainty (Angus et al., 2023) or, how Packard and Clark (2020) call it, epistemic uncertainty and aleatory uncertainty.

The developed epistemological contingency framework suggests the assignment of decision situations to specific levels of contingency. In order to reduce contingency in decision-making, organizations can control for subjectively given and objectively available knowledge to evaluate decision-making strategies. Further research should aim to explore more about the types of knowledge within levels of contingency (e.g., declarative/accumulated knowledge, procedural/structural knowledge, conceptual knowledge) and match them with decision-making strategies (including the most commonly used ones: effectuation, causation, bricolage, but also beyond). This will lead to a better understanding of situation-specific decision-making strategies. It will also help organizations to choose strategies to consciously and effectively reduce contingency in decision-making situations. Harms, Alfert, Cheng & Kraus (2021) have recently undertaken an initiative in this direction. The authors find that the successful innovation of business models depends on the successful adaptation of appropriate decision strategies to the decision situations.

Contribution to decision-making theory

In order to outline effective decision-making, differentiations within the original concept of uncertainty are necessary. This paper shows that in order to avoid synonymous use and lack of differentiation, different levels of contingency can replace the generic term uncertainty (i.b.s.). An understanding of uncertainty (i.b.s.) can still be meaningfully applied, as it exists in the form of two major types (Type A and Type B uncertainty). Their classification generally results from the relationship between completeness and incompleteness of information or data. Type A uncertainty represents an objective problem, while Type B uncertainty relates only to the agent. The distinction between objective and subjective uncertainty has implications for choosing effective decision-making strategies as well as for measuring decision-making.

The measurement of contingency perception in empirical studies as a predictive element for decision-making has to take into account that measurement results depend on the units of investigation (respondents) as well as on the objects of investigation (see e.g. Angus et al., 2023). Depending on individual expertise, agents update more or less limited amounts of information from their environment. On this basis, they coordinate their behavior. This is normal in cases of (perceived) imperfect information, which agents often encounter when decision-making[4], without recognizing or collecting the maximum possible amount and quality of information before acting (Busenitz & Barney, 1997; McMullen & Kier, 2016). From a subjective perspective, although information about outcomes, relevant variables, probabilities, and causal relationships may be (objectively) available, decision-making situations may be individually assigned to higher/more complex levels of contingency. This way, the context of decision-making (in terms of available knowledge) may be misinterpreted, leading to ineffective decision strategies (Packard & Clark, 2020) (e.g. applying adaptive, flexible approaches in situations of low contingency instead of predictive, planning approaches).

By deliberately generating knowledge and filling information gaps, a better understanding of objective contingency in specific decision situations enables agents to select more appropriate strategies for effective decision-making. The proposed conceptualization of an epistemological contingency framework helps to address the question of whether strategists should adapt or shape markets on the basis of specific constituent elements such as intentions, epistemologies, and enactment strategies (Rindova & Courtney, 2020). In addition to individual dispositions, such as being risk-averse or risk-seeking, and operational capabilities, the outlined levels of contingency clarify the role of epistemologies in understanding the incompleteness of information and concluding coping or mitigating strategies in contingency situations. To conclude, the following steps are suggested for identifying levels of contingency and concluding effective strategies for reducing them.

1. The exclusivity of the decision problem must be questioned in order to objectively classify a decision situation: Is the problem objectively and/or subjectively given? Are objective information/solutions available (e.g., expert knowledge, market research approaches)?
2. If subjective information gaps or deficiencies are identified, but objective information is available, how can the gap be filled by updating subjectivity (e.g., deliberate own research, factor market expertise, trial & error, effectuation)? This reflects the effectiveness of the decision-making process, as all decision-making strategies require resources.

[4] E.g. Applying trial & error according to Hauser, Eggers & Güldenberg, (2020).

3. If objective information gaps are identified, how can contingency be reduced (e.g. by developing reduction strategies such as deliberate experimentation)?

Given the framework and corresponding recommendations, the paper sharpens the microfoundations of decision-making in general and in dynamic environments in particular. The provided understanding of contingency and its configurations allows agents to infer strategies for acquiring information and making successful decisions. Studies such as the one by Magruk (2021) can be supported by this when it comes to discussing foresight methodologies in situations of emerging technologies.

Implications and further research

In order to make decision strategies more applicable to epistemologically diverse decision situations, widely discussed decision-making paradigms (effectuation, causation, bricolage etc.) need to be revisited and more clearly differentiated. For example, some paradigms are constructed in an overlapping manner, which leads to incomplete recognition of all existing decision strategies within empirical studies. For example, anything apart from causation is often labeled effectuation, although it is not distinguished from trial and error (or other paradigms.) After the revision and differentiation of the paradigms, their effect on the reduction of contingency must be investigated. To what extent specific decision strategies contribute to the reduction of contingency in order to effectively enable reliable decisions would be an appropriate avenue of research. The answer to this question requires an alignment between the variations of decision-making paradigms (including their inherent types of knowledge, their transition, and their transferability) and their assignment to different levels of contingency. The study of knowledge generation among scientists in the context of the SARS-CoV-2 pandemic would be an interesting, if not primarily managerial, research case. At the beginning of 2020, German scientists knew very little about the virus in terms of transmission (aerosol vs. smear infection, etc.), resistance to temperature and ultraviolet light, or the effects of preventive tools. By 2022, researchers were able to predict infections and incidences over 6 months in advance with almost no deviation. This included variations in instrumental scenarios. The case illustrates an archetypal development of knowledge and how to transform this into a simulated, prediction-based model. A publication by Gričar and Bojnec (2022) provides another example of the development and application of such a model.

The application of *fuzzy logic* or even *supervaluationism* to the presented epistemological contingency framework would be another highly interesting avenue of further research. Fuzzy logic is based on fuzzy sets, in contrast to conventional *Boolean* logic. In both models, a property of an object is defined as membership of a set, but in fuzzy logic membership is progressively less sharply defined by a 0/1 (yes/no) distinction. Attribution is made formally by assigning a numerical value from an interval to each element as a degree of membership, or linguistically by accepting fuzziness in transition states (Klir, G. J., Zadeh, L. A [Lotfi A.], & Zadeh, L. A [Lotfi Asker, 1996)[5]. However, in linguistic semantics today, fuzzy logic is generally considered unsuitable for modeling vagueness and similar phenomena in natural language (Kamp & Partee, 1995; Sauerland, 2012). Instead of the assignment of an indeterminate statement, the method of supervaluation is preferred. Here, the assignment of a classical truth value (0;1) is postponed because its classification is not yet clear, or it depends on a parameter that must be substantiated by information from the context (Kamp & Partee, 1995). Such cases are well characterized by contingency levels of complexity and above. They involve indeterminable variables and cannot yet be unambiguously classified as true or false (Rinard, 2014). The application of supervaluation to the levels of contingency described above can help to identify the intersections between certain levels, according to the given qualities of the knowledge. On this basis, gaps in knowledge can be identified, filled by a deliberate accumulation of knowledge, and finally, transitions and strategies that allow for the transition between the levels of contingency can become visible.

Authorship

Conceptualization, methodology, visualization, writing original draft, writing-review-editing: Sebastian L. Grüner

E.g. “Back up the car a little bit more, please!” instead of “Back up the car 12,5cm more, please!”.

References

Angus, R. W., Packard, M. D., & Clark, B. B. (2023). Distinguishing unpredictability from uncertainty in entrepreneurial action theory. *Small Business Economics*, *60*(3), 1147–1169. https://doi.org/10.1007/s11187-022-00651-4

Arend, R. J. (2022). Strategic decision-making under ambiguity: insights from exploring a simple linked two-game model. *Operational Research*, *22*(5), 5845–5861. https://doi.org/10.1007/s12351-022-00728-8

Arend, R. J., Sarooghi, H., & Burkemper, A. (2015). Effectuation as ineffectual? Applying the 3E theory-assessment framework to a proposed new theory of entrepreneurship. *The Academy of Management Review*, *40*(4), 630–651. https://doi.org/10.5465/amr.2014.0455

Ariely, D. (2010). *Predictably irrational: The hidden forces that shape our decisions*. Harper Collins https://doi.org/10.1037/e653632011-003

Aristotle, & Sachs, J. (2002). *Aristotle's metaphysics*. Green Lion Press.

Ashby, W. R. (1956). *An Introduction to Cybernetics*. Chapman & Hall. https://doi.org/10.5962/bhl.title.5851

Audretsch, D. B., & Belitski, M. (2021). Frank Knight, uncertainty and knowledge spillover entrepreneurship. *Journal of Institutional Economics*, *17*(6), 1005–1031. https://doi.org/10.1017/S1744137421000527

Barr, C., Doyle, M., Clifford, J., Leo, T. de, & Dubeau, C. (2003). *There's more to math: A framework for learning and instruction.* Waterloo Catholic District School Board.

Beer, S. (1994). *Decision and Control: The meaning of Operational Research and Management Cybernetics*. Wiley & Sons.

Berge, T. ten, & Hezewijk, R. van (1999). Procedural and declarative knowledge. *Theory & Psychology*, *9*(5), 605–624. https://doi.org/10.1177/0959354399095002

Berglund, H., Bousfiha, M., & Mansoori, Y. (2020). Opportunities as artifacts and entrepreneurship as design. *Academy of Management Review*, *45*(4), 825–846. https://doi.org/10.5465/amr.2018.0285

Busenitz, L. W., & Barney, J. B. (1997). Differences between entrepreneurs and managers in large organizations: biases and heuristics in strategic decision-making. *Journal of Business Venturing*, *12*(1), 9–30. https://doi.org/10.1016/S0883-9026(96)00003-1

Camerer, C., & Weber, M. (1992). Recent developments in modeling preferences: uncertainty and ambiguity. *Journal of Risk and Uncertainty*, *5*(4), 325–370. https://doi.org/10.1007/BF00122575

Campos, F., Neves, A., & Campello de Souza, F. M. (2007). Decision-making under subjective uncertainty. In *2007 IEEE Symposium on Computational Intelligence in Multi-Criteria Decision-Making*. https://doi.org/10.1109/MCDM.2007.369421

Chandler, G. N., DeTienne, D. R., McKelvie, A., & Mumford, T. V. (2011). Causation and effectuation processes: a validation study. *Journal of Business Venturing*, *26*(3), 375–390. https://doi.org/10.1016/j.jbusvent.2009.10.006

Clarysse, B., Bruneel, J., & Wright, M. (2011). Explaining growth paths of young technology-based firms: structuring resource portfolios in different competitive environments. *Strategic Entrepreneurship Journal*, *5*(2), 137–157. https://doi.org/10.1002/sej.111

Crawford, G. C., Aguinis, H., Lichtenstein, B., Davidsson, P., & McKelvey, B. (2015). Power law distributions in entrepreneurship: implications for theory and research. *Journal of Business Venturing*, *30*(5), 696–713. https://doi.org/10.1016/j.jbusvent.2015.01.001

Daft, R. L., Lengel, R. H., & Trevino, L. K. (1987). Message equivocality, media selection, and manager performance: implications for information systems. *MIS Quarterly*, *11*(3), 355–366. https://doi.org/10.2307/248682

Daft, R. L., & Macintosh, N. B. (1981). A Tentative exploration into the amount and equivocality of Information processing in organizational work units. *Administrative Science Quarterly*, *26*(2), 207–224 https://doi.org/10.2307/2392469

Daft, R. L., & Weick, K. E. (1984). Toward a model of organizations as interpretation systems. *The Academy of Management Review*, *9*(2), 284–295. https://doi.org/10.2307/258441

Davis, J. P., Eisenhardt, K. M., & Bingham, C. B. (2009). optimal structure, market dynamism, and the strategy of simple rules. *Administrative Science Quarterly*, *54*(3), 413–452. https://doi.org/10.2189/asqu.2009.54.3.413

Dequech, D. (2011). Uncertainty: a typology and refinements of existing concepts. *Journal of Economic Issues*, *45*(3), 621–640. https://doi.org/10.2753/JEI0021-3624450306

Descartes, R. (Ed.). (1996). *Cambridge texts in the history of philosophy*. *Meditations on first philosophy: With selections from the Objections and Replies* (Rev. ed.). Cambridge Univ. Press https://doi.org/10.1017/CBO9780511805028.019

Dew, N., Read, S., Sarasvathy, S. D., & Wiltbank, R. (2009). Effectual versus predictive logics in entrepreneurial decision-making: differences between experts and novices. *Journal of Business Venturing*, *24*(4), 287–309. https://doi.org/10.1016/j.jbusvent.2008.02.002

Dosi, G., & Egidi, M. (1991). Substantive and procedural uncertainty. *Journal of Evolutionary Economics*, *1*(2), 145–168. https://doi.org/10.1007/BF01224917

Downey, H. K., & Slocum, J. W. (1975). Measures, research, and sources of variation. *The Academy of Management Journal*, *18*(3), 562–578. https://doi.org/10.2307/255685

Ellsberg, D. (1961). Risk, ambiguity, and the savage axioms. *The Quarterly Journal of Economics*, *75*(4), 643–669. https://doi.org/10.2307/1884324

Foerster, H. von. (1985). *Sicht und Einsicht: Versuche zu einer operativen Erkenntnistheorie*. Springer https://doi.org/10.1007/978-3-663-13942-3

Foerster, H. von. (2011). *Wissen und Gewissen: Versuch einer Brücke* (1. Aufl. [Nachdr.]. *Suhrkamp-Taschenbuch Wissenschaft: Vol. 876*. Suhrkamp.

Foerster, H. von, & Pörksen, B. (2023). *Wahrheit ist die Erfindung eines Lügners: Gespräche für Skeptiker* (13th ed.). *Systemische Horizonte*. Carl Auer Verlag.

Fox, C. R., & Tversky, A. (1995). Ambiguity aversion and comparative ignorance. *The Quarterly Journal of Economics*, *110*(3), 585–603. https://doi.org/10.2307/2946693

Freiling, J. (2008). RBV and the road to the control of external organizations. *Management Revue*, *19*(1/2), 33–52. http://www.jstor.org/stable/41783570

Frishammar, J., Florén, H., & Wincent, J. (2011). Beyond managing uncertainty: insights from studying equivocality in the fuzzy front end of product and process innovation projects. *IEEE Transactions on Engineering Management*, *58*(3), 551–563. https://doi.org/10.1109/TEM.2010.2095017

Garud, R., & van de Ven, A. H. (1992). An empirical evaluation of the internal corporate venturing process. *Strategic Management Journal*, *13*(S1), 93–109. https://www.jstor.org/stable/2486354

Grégoire, D. A., & Cherchem, N. (2020). A structured literature review and suggestions for future effectuation research. *Small Business Economics*, *54*(3), 621–639. https://doi.org/10.1007/s11187-019-00158-5

Gričar, S., & Bojnec, Š. (2022). Did human microbes affect tourist arrivals before the COVID-19 shock? Pre-effect forecasting model for Slovenia. *International Journal of Environmental Research and Public Health*, *19*(20). https://doi.org/10.3390/ijerph192013482

Griffin, M. A., & Grote, G. (2020). When is more uncertainty better? A model of uncertainty regulation and effectiveness. *Academy of Management Review*, *45*(4), 745–765. https://doi.org/10.5465/amr.2018.0271

Harms, R., Alfert, C., Cheng, C.-F., & Kraus, S. (2021). Effectuation and causation configurations for business model innovation: Addressing COVID-19 in the gastronomy industry. *International Journal of Hospitality Management*, *95*, 102896. https://doi.org/10.1016/j.ijhm.2021.102896

Hauser, A., Eggers, F., & Güldenberg, S. (2020). Strategic decision-making in SMEs: effectuation, causation, and the absence of strategy. *Small Business Economics*, *54*(1), 775-790. https://doi.org/10.1007/s11187-019-00152-x

Hmieleski, K. M., & Corbett, A. C. (2006). Proclivity for improvisation as a predictor of entrepreneurial intentions. *Journal of Small Business Management*, *44*(1), 45–63. https://doi.org/10.1111/j.1540-627X.2006.00153.x

Hoffman, F. O., & Hammonds, J. S. (1994). Propagation of uncertainty in risk assessments: the need to distinguish between uncertainty due to lack of knowledge and uncertainty due to variability. *Risk Analysis*, *14*(5), 707–712. https://doi.org/10.1111/j.1539-6924.1994.tb00281.x

Holm, H. J., Opper, S., & Nee, V. (2013). Entrepreneurs under uncertainty: an economic experiment in China. *Management Science*, *59*(7), 1671–1687. https://www.jstor.org/stable/23443876

Hume, D. (2021). *A treatise of human nature*. Lokis Publishing; [manufacturer not identified].

Kahneman, D., & Tversky, A. (1979). Prospect theory. An analysis of decision under risk. *Econometrica*, *47*(2), 263–291. https://doi.org/10.2307/1914185

Kamp, H., & Partee, B. (1995). Prototype theory and compositionality. *Cognition*, *57*(2), 129–191. https://doi.org/10.1016/0010-0277(94)00659-9

Klir, G. J., Zadeh, L. A [Lotfi A.], & Zadeh, L. A [Lotfi Asker] (Eds.). (1996). *Advances in fuzzy systems - applications and theory: Vol. 6. Fuzzy sets, fuzzy logic, and fuzzy systems: Selected papers*. World Scientific.

Knight, F. H. (1964). *Risk, Uncertainty and Profit*. Hougthon Mifflin Company.

Krohn, W., & Krücken, G. (1993). Risiko als Konstruktion und Wirklichkeit. Eine Einführung in die sozialwissenschaftliche Risikoforschung. In W. Krohn & G. Krücken (Eds.), *Riskante Technologien: Reflexion und Regulation. Einführung in die sozialwissenschaftliche Risikoforschung* (pp. 9–44). Suhrkamp.

Kuechle, G., Boulu-Reshef, B., & Carr, S. D. (2016). Prediction- and control-based strategies in entrepreneurship: the role of information. *Strategic Entrepreneurship Journal*, *10*(1), 43–64. https://doi.org/10.1002/sej.1211

Laux, H., Gillenkirch, R. M., & Schenk-Mathes, H. Y. (2014). *Entscheidungstheorie* (9th ed.). Springer.

Lorenz, K. A. (1975). *Die Rückseite des Spiegels. Versuch einer Naturgeschichte menschlichen Erkennens*. Piper.

Magruk, A. (2021). Analysis of uncertainties and levels of foreknowledge in relation to major features of emerging technologies: the context of foresight research for the fourth industrial revolution. *Sustainability*, *13*(17), 9890. https://doi.org/10.3390/su13179890

March, J. G. (1994). *Primer on Decision-making: How Decisions Happen*. Free Press.

March, J. G., & Shapira, Z. (1987). Managerial perspectives on risk and risk taking. *Management Science*, *33*(11), 1404–1418. https://www.jstor.org/stable/2631920

Mathiaszyk, L. P. (2017). *Corporate effectuation: Effectual strategy for corporate management* [, University of Wuppertal – Bergische Universität Wuppertal]. BibTeX.

McMullen, J. S., & Kier, A. S. (2016). Trapped by the entrepreneurial mindset: opportunity seeking and escalation of commitment in the mount everest disaster. *Journal of Business Venturing*, *31*(6), 663–686. https://doi.org/10.1016/j.jbusvent.2016.09.003

Miller, J. I. (2012). The mortality problem of learning and mimetic practice in emerging industries: dying to be legitimate. *Strategic Entrepreneurship Journal*, *6*(1), 59–88. https://doi.org/10.1002/sej.1128

Milliken, F. J. (1987). Three types of perceived uncertainty about the environment: state, effect, and response uncertainty. *The Academy of Management Review*, *12*(1), 133–143. https://doi.org/10.2307/257999

Mitchell, R. K., Busenitz, L., Lant, T., McDougall, P. P., Morse, E. A., & Smith, J. B. (2002). Toward a theory of entrepreneurial cognition: rethinking the people side of entrepreneurship research. *Entrepreneurship Theory and Practice*, *27*(2), 93–104. https://doi.org/10.1111/1540-8520.00001

Nonaka, I., & Takeuchi, H. (1995). *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford University Press. https://doi.org/10.1093/oso/9780195092691.001.0001

Nonaka, I., & Toyama, R. (2007). Strategic management as distributed practical wisdom (Phronesis). *Industrial and Corporate Change*, *16*, 371–394. https://doi.org/10.1093/icc/dtm014

Oehmen, J., & Kwakkel, J. (2020). Risk, uncertainty, and ignorance in engineering systems design. In A. Maier, J. Oehmen, & P. E. Vermaas (Eds.), *Handbook of engineering systems design* (pp. 1–32). Springer International Publishing. https://doi.org/10.1007/978-3-030-46054-9_10-2

Ogden, C. (n.d.). *Killed by Google*. Retrieved January 3, 2024, from https://killedbygoogle.com/

Otto, F. E. (2023). Attribution of extreme events to climate change. *Annual Review of Environment and Resources*, *48*(1), 813–828. https://doi.org/10.1146/annurev-environ-112621-083538

Packard, M. D., Bylund, P. L., & Clark, B. B. (2021). Keynes and Knight on uncertainty: peas in a pod or chalk and cheese? *Cambridge Journal of Economics*, *45*(5), 1099–1125. https://doi.org/10.1093/cje/beab025

Packard, M. D., & Clark, B. B. (2020). On the mitigability of uncertainty and the choice between predictive and nonpredictive strategy. *Academy of Management Review*, *45*(4), 766–786. https://doi.org/10.5465/amr.2018.0198

Packard, M. D., Clark, B. B., & Klein, P. G. (2017). Uncertainty types and transitions in the entrepreneurial process. *Organization Science*, *28*(5), 840–856. https://doi.org/10.1287/orsc.2017.1143

Polanyi, M. (1966). *The tacit dimension*. Doubleday & Company.

Ramoglou, S. (2021). Knowable opportunities in an unknowable future? On the epistemological paradoxes of entrepreneurship theory. *Journal of Business Venturing*, *36*(2), 106090. https://doi.org/10.1016/j.jbusvent.2020.106090

Read, S., Sarasvathy, S. D., Dew, N., & Wiltbank, R. (2016). Response to Arend, Sarooghi, and Burkemper (2015): Cocreating effectual entrepreneurship research. *The Academy of Management Review*, *41*(3), 528–536. https://doi.org/10.5465/amr.2015.0180

Rinard, S. (2014). The principle of indifference and imprecise probability. *Thought: A Journal of Philosophy*, *3*(2), 110–114. https://doi.org/10.1002/tht3.118

Rindova, V., & Courtney, H. (2020). To shape or adapt: Knowledge problems, epistemologies, and strategic postures under Knightian uncertainty. *Academy of Management Review*, *45*(4), 787–807. https://doi.org/10.5465/amr.2018.0291

Rindova, V., Ferrier, W. J., & Wiltbank, R. (2010). Value from Gestalt: How sequences of competitive actions create advantage for Firms in nascent markets. *Strategic Management Journal*, *31*(13), 1474–1497. https://doi.org/10.1002/smj.892

Sanchez, R. (2005). 'Tacit knowledge' versus 'explicit knowledge' Approaches to knowledge management practice. In D. Rooney, G. Hearn, & A. Ninan (Eds.), *on the Knowledge Economy* (pp. 191–203). Edward Elgar. https://doi.org/10.4337/9781845426842.00025

Sarasvathy, S. D. (2001). Causation and effectuation: Toward a theoretical shift from economic inevitability to entrepreneurial contingency. *The Academy of Management Review*, *26*(2), 243–263. https://doi.org/10.2307/259121

Sarasvathy, S. D. (2008). *Effectuation: Elements of entrepreneurial expertise*. Edward Elgar. https://doi.org/10.4337/9781848440197

Sarasvathy, S. D., & Kotha, S. (2001). Managing Knightian uncertainty in the new economy: the RealNetworks case. In J. Butler (Ed.), *E-Commerce and Entrepreneurship (Hc) (Research in Entrepreneurship and Management)* (pp. 31–62). Information Age Publishing.

Sauerland, U. (2012). Vagueness in language: The case against fuzzy logic revisited. In P. Cintula, C. G. Fermueller, & L. Godo (Eds.), *Studies in logic: Vol. 36. Understanding vagueness: Logical, philosophical, and linguistic perspectives* (pp. 185–198). College Publ.

Savage, L. J. (1972). *The Foundations of Statistics* (2nd ed.). Dover Publications.

Schneider, D. (1997). *Theorie der Unternehmung*. de Gruyter.

Seghers, A., Manigart, S., & Vanacker, T. (2012). The impact of human and social capital on entrepreneurs' knowledge of finance alternatives. *Journal of Small Business Management*, *50*(1), 63–86. https://doi.org/10.1111/j.1540-627X.2011.00344.x

Shackle, G. L. S. (2010). *Uncertainty in Economics and Other Reflections*. Cambridge Univ. Press.

Sharot, T., & Sunstein, C. R. (2020). How people decide what they want to know. *Nature Human Behaviour*, *4*(1), 14–19. https://doi.org/10.1038/s41562-019-0793-1

Shepherd, D. A., & Patzelt, H. (2018). *Entrepreneurial cognition: Exploring the mindset of entrepreneurs*. Palgrave Macmillan. https://doi.org/10.1177/0149206314541153

Shepherd, D. A., Williams, T. A., & Patzelt, H. (2015). Thinking about entrepreneurial decision-making: Review and research agenda. *Journal of Management*, *41*(1), 11–46. https://doi.org/10.1177/0149206314541153

Shubik, M. (1954). Information, risk, ignorance, and indeterminacy. *The Quarterly Journal of Economics*, *68*(4), 629. https://doi.org/10.2307/1881881

Sniazhko, S. (2019). Uncertainty in decision-making: a review of the international business literature. *Cogent Business & Management*, *6*(1), Article 1650692. https://doi.org/10.1080/23311975.2019.1650692

Sorenson, O., & Stuart, T. E. (2008). Entrepreneurship: a field of dreams? *Academy of Management Annals*, *2*(1), 517–543. https://doi.org/10.5465/19416520802211669

Spender, J.-C. (1989). *Industry recipes: An enquiry into the nature and sources of managerial judgement*. Teilw. Zugl.: Manchester, Univ., Diss., 1980. Blackwell.

Spinoza, B. de. (2003). *The Ethics: Ethica Ordine Geometrico Demonstrata*. Retrieved December 21, 2023, from https://www.gutenberg.org/files/3800/3800-h/3800-h.htm

Stirling, A. (2010). Keep it complex. *Nature*, *468*(7327), 1029–1031. https://doi.org/10.1038/4681029a

Sutcliffe, K. M., & Zaheer, A. (1998). Uncertainty in the transaction environment: an empirical test. *Strategic Management Journal*, *19*(1), 1–23. Retrieved November 8, 2023, from https://www.jstor.org/stable/30941771

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, *28*(13), 1319–1350. https://doi.org/10.1002/smj.640

Teece, D. J. (2012). Dynamic capabilities: routines versus entrepreneurial action. *Journal of Management Studies*, *49*(8), 1395–1401. https://doi.org/10.1111/j.1467-6486.2012.01080.x

Thompson, J. D. (2017). *Organizations in action*. Routledge. https://doi.org/10.4324/9781315125930

Townsend, D. M., Hunt, R. A., McMullen, J. S., & Sarasvathy, S. D. (2018). Uncertainty, knowledge problems, and entrepreneurial action. *Academy of Management Annals*, *12*(2), 659–687. https://doi.org/10.5465/annals.2016.0109

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science*, *211*(30), 453–458. https://doi.org/10.1126/science.7455683

Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, *5*(4), 297–323. https://doi.org/10.1007/BF00122574

U.S. Bureau of Labor Statistics. (2023). *Survival of private sector establishments by opening year*. Retrieved January 12, 2024, from https://www.bls.gov/bdm/us_age_naics_00_table7.txt

Weick, K. E. (1995). *Sensemaking in organizations*. SAGE.

Wiklund, J., & Shepherd, D. (2003). Knowledge-based resources, entrepreneurial orientation, and the performance of small and medium-sized businesses. *Strategic Management Journal*, *24*(13), 1307–1314. https://doi.org/10.1002/smj.360

York, J. G., & Venkataraman, S. (2010). The entrepreneur-environment nexus: uncertainty, innovation, and allocation. *Journal of Business Venturing*, *25*(5), 449–463. https://doi.org/10.1016/j.jbusvent.2009.07.007

✉ Correspondence

Sebastian L. Grüner

RheinMain University of Applied Sciences
Kurt-Schumacher-Ring 18, 65197 Wiesbaden, Germany

E-mail: sebastian.gruener@hs-rm.de