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Sebastian L. Grüner
Department of Mathematics, Natural and
Economic Sciences
Ulm University of Applied Sciences
89075 Ulm, Germany
sebastian.gruener@thu.de

REFRAMING TYPES OF UNCERTAINTY AS A STARTING POINT FOR EFFICIENT DECISION MAKING

Abstract:
Purpose: Mangerial decision-making situations are often confronted with uncertainty in terms of underlying causes and predictable effects. However, overlapping definitions and conflicting operationalization of the uncertainty construct make it difficult to deliberately face different types of unceratinby with specific decision-making strategies. The paper aims at delineating types of uncertainty along specific knowledge contexts to enable the choice of suitable strategies for specific decision-making situations.
Design/methodology/approach: In a literature review, concepts of (un)certainty based on (im)perfect information and objectively/ subjectively available configurations of knowledge are discussed and revised.
Findings: The paper develops a framework comprising differentiated states of available information and knowledge applicable to decision-making situations. To unburden the uncertainty concept from conflicting definitions and heterogeneous operationalization, the umbrella-term contingency is introduced. It overarches all states of (im)perfect information and various configurations of knowledge. Finally a framework is presented that delineates different levels of contingency by distinguishing between certainty, risk, uncertainty in the narrowest sense [i.n.s.], complexity, ambiguity/ equivocality and isotropy/ radical uncertainty.
Research limitations/implications: 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 and contextual factors (i.e., time, resources) into account.
Practical implications: Based on the findings, decision-making situations can be clarified in terms of their level of contingency and appropriate strategies to reduce contingency can be developed.

Keywords: uncertainty, decision making, knowledge, contingence

INTRODUCTION

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 decision makers (Ariely 2010; Kahneman and Tversky 1979; Tversky and Kahneman 1981). Others have rather focused on dealing with situational constraints (e.g. scarcity of resources and time) (Hmieleski and Corbett 2006; Shepherd et al. 2015) or heuristic strategies (e.g. effectuation) to tackle imperfect information (Dew et al. 2009; Sarasvathy 2001).
Knowledge thereby has been identified as a critical variable for dealing and conceptualizing uncertainty. Knowledge and experience of decision makers influence how they make decisions and realize business opportunities (Shepherd et al. 2015). It generally favors the identification of future states and outcomes in general (Shepherd and Patzelt 2018) and in special fields (e.g. identifying more financing opportunities) (Seghers et al. 2012). At organizational level, knowledge as

a bundle of intangible resources is considered as sustained and effective instrument for gaining and maintaining competitive advantages (Wiklund and Shepherd 2003) and in consequence 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). Knowledge is declared to be the fundament of competencies whereas competences mean the ability to establish and repeat knowledge-based regular (not random) processes to achieve future market action and maintenance (Freiling 2008). In conclusion, knowledge and knowledge generating routines help dealing with uncertainty. However, the conceptualization of uncertainty remains inconsistent. Degrees and types of uncertainty are neither clearly distinct nor selectively defined, which makes it difficult to conclude specific (practical) solutions (i.e. decision-making strategies) from specific types of uncertainty. Aside to neglecting the role of individual decision makers, the ongoing debate has also not yet provided a concept incorporating a uniform understanding of acknowledged types of uncertainty (Sniazhko 2019). Several approaches have been undertaken to distinguish dimensions of uncertainty. Knight (1964 [1921]) first differentiates between risk and uncertainty (Knightian uncertainty), whereas both dimensions depend on knowledge about outcomes and probabilities. A similar but more specific approach is presented by Milliken (1987) who identify three types of uncertainty. State uncertainty reflects a decision makers inability to predict developments of the organization´s environment due environmental dynamism and complexity. Response uncertainty occurs when no specific actions are known to decision makers to tackle state uncertainty. And effect uncertainty is present if consequences of actions are unknown or unpredictable to decision makers. Subsequent research by Dequech (2011) adds another dimension to the typology of uncertainty by differentiating between lacks of information and lacks of operational ability. One side of the identified uncertainty scale is labeled also weak uncertainty similar to risk represented by knowledge about outcomes and probabilities. Strong uncertainty on the other side arises from neither knowing possible outcomes (fundamental uncertainty) nor probability of outcomes due to missing information (ambiguity). Furthermore strong uncertainty occurs in situations in which causal relationships between outcomes and actions are unknown (procedural uncertainty), which makes Dequechs approach compatible to research about types of knowledge (Barr et al. 2003; Berge and Hezewijk 1999; Nonaka and Takeuchi 1995; Nonaka and Toyama 2007; Sanchez 2005). Latest research on dimensions of uncertainty elaborate on these approaches by merging their findings. They incorporate subjective and objective perceptions of uncertainty as well as further detailing of knowledge-related dimensions. Packard et al. (2017) differentiate risk and ambiguity from environmental uncertainty, creative uncertainty and absolute uncertainty. In line with Knight (1964 [1921]), risk is defined by the present degree of knowledge about outcomes and probability. However, their understanding of ambiguity diverges from Knightian uncertainty in the way that for the former outcomes are known but probabilities are not, whereas for the latter neither outcomes nor probabilities are known.[1] Environmental uncertainty reflects situations in which outcomes are not fully known (yet) and hence is similar to state uncertainty according to Milliken (1987). Creative uncertainty is represented by knowing the outcomes but not knowing the underlying causalities or processes and absolute uncertainty is present when neither outcomes nor underlying causalities or processes are known. By revising literature and existing concepts, the paper aims at delineating types of uncertainty to provide a holistic framework of contingency and that are defined by specific knowledge configurations. First, the idea of *contingency* is introduced in order to unburden the uncertainty concept from conflicting definitions and heterogeneous operationalization. Second, types and dimensions of contingency are discussed. Thereby initially the concept of *certainty* becomes examined in order to demark further configurations of contingency. Of central importance remains the concept of *uncertainty*, but it is treated and dissected in more specificity and detail. Variations of contingency (*certainty, risk, uncertainty in the narrowest sense [i.n.s.]*, *complexity*, *ambiguity/ equivocality*, *isotropy/ radical uncertainty*) are presented successively. Third, configurations of contingency become aggregated to a contingency framework and forth, implications for further research avenues towards strategies to reduce contingency to enable efficient decision making are concluded.

TYPES OF UNCERTAINTY/ CONTINGENCY

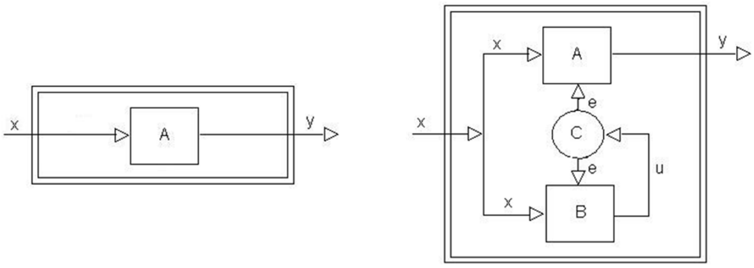
In order to avoid terminological confusion, the umbrella-term of uncertainty becomes renamed as contingency. Contingency hereby refers to a specific openness of opportunities and options. Contingent situations are characterized by coincidences which means that something might happen or might not happen, that something might be true or not be true. Types of contingency embrace different levels of what is known and what can be known in terms of specific decision-making situations. Lower levels of contingency represent situations of (almost) perfect information, higher levels represent decreasing information quality. Contingence replaces the umbrella-term of uncertainty in order to enable coverage of different types of uncertainty and beyond.

Types of contingence are outlined in the following chapter. Their level depends on the availability of specific knowledge dimensions. These comprise the knowledge of all possible outcomes and relevant variables, the knowledge of probabilities of all possible outcomes and relevant variables, the knowledge of succession of outcome-related variables and the knowledge of causal relationship of outcome-related variables/ distinctiveness of all variables. The discussed types of contingency increasing in level are *certainty, risk, uncertainty (i.n.s.), complexity, ambiguity/ equivocality* and *isotropy/ radical uncertainty*.

[1] An understanding that will be discussed in this paper later.

Certainty

Certainty represents the lowest level of contingency and marks the starting point of the contingency framework. Certainty is ascribed to situations that are characterized being trivial because they have only one (reasonable) state. In trivial situations a given, specific input always generates a specific concludable output (just like an equation with on variable). Triviality assumes a distinct causal relationship between input and output (Foerster 1985). In comparison, non-trivial situations may have at least two states, i.e. they provide one output or another output for the same input (Foerster and Pörksen 2023). The distinction is illustrated by **Picture 1**.



Picture 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, decision makers possess knowledge of all possible outcomes as well as their probabilities (Laux et al. 2014). In case there are sequences of events (variables) decision makers are intimate with follow-ups (succession of event-related elements) and final outcomes. I.e.: a stoplight will turn green in a fixed and known period of time after it turns red. It will also turn a definite number of seconds after the pedestrian light turns red which might indicate to the decision maker that it is time to engage the first gear of the car. Knowledge about regularities of processes, sequences, causalities and the differentiability of its intermediate events (variables) enable decision makers to be certain about outcomes. The same applies to situations where the stop light is turned off. Decision makers that are familiar with the situation will very likely not be waiting for the stoplight to turn green. They can clearly determine which alternative courses of action are available in known situations and which outcomes follow from states of the situation and their choice. The expected value of all future events is one and all alternatives to a choice represent "certain" alternatives. Situations of triviality are situations of low contingence and hence situations of certainty.

Risk

Formal and engineering sciences as well as the insurance industry define *risk* as a stochastically and calculable quantity, which is aggregated in the form of an expectancy value. The expectancy value of outcomes results, simplified, as the product of the expected amount of damage/ loss (or benefit/ gain) and the probability that an outcome occurs (Krohn and Krücken 1993). A definition as such presupposes the quantifiability of involved variables and intermediate states, which is commonly achieved by stochastic or empirical methods. Insurance companies can quantify risks and contract costs if they know the number of potential policyholders, the frequencies of insured events and the amount of damages. This may also include single risks for certain contracts (e.g. insured damage by martens additional to part insurance cover), with risk becoming the target variable of a mathematical calculation (Laux et al. 2014).

Other than formal science, social sciences such as business administration are confronted with the challenge that variables for risk calculation are often not or only incompletely quantifiable, if not even unknown. Against the background of bounded rationality, social theory preferably deals with (non-)presence of information in the context of risk. This does not necessarily exclude proximity calculations ("[...] risk is most commonly conceived as reflecting variations in the distribution of possible outcomes" (March and 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 and Shapira 1987, p. 1404)). Hence, the concept of risk operationalized in social sciences is not strictly formal, insofar as it integrates the possibility of experience-based probabilities and allows for incomplete (because partially impossible) calculations.

For the development of a contingency-based decision-making framework, the question arises to what extent the concept of risk should be kept multifold (formal and/or social scientific). It appears in terms of distinctiveness less appropriate. Also, the social-scientific perspective of risk incorporates contingency determining variables, which are as well object of the level uncertainty (see chapter Uncertainty). This suggests the operationalization of risk according rather to a formal concept. Given this understanding is a situation declared to be risky if all possible outcomes and variables as well as their probabilities of occurrence are known. However, risk includes a lack of knowledge of causal relationships between related variables. Although decision makers a) might be knowing what can happen next (possible outcomes), they b) might be able to tell the probability of any possible outcome, c) are familiar with the succession of outcome-related variables but d) are lacking about the causal relationship of outcome-related variables. A typical example for risky situations is tossing a coin. Outcomes are known (heads or tails), probabilities are known (50/50), succession of outcome-related variables (tossing, dropping, bopping around) are known but the outcome is not specifically determinable (physics behind outcome) due to the inability to control underlying causalities that lead to the outcome (head or tails). Additionally, risky situations are characterized by the prerequisite of being repeatable. Only the repetition of a situation (e.g. tossing a coin over and over again) with stable input, a restricted number of variables and subsequent output states enables the calculation of probabilities for the output (i.e.: ~ 50/50 out of 1000 attempts). This is especially an empirical challenge for more complex situations as estimates of probabilities depend on the repetitions determined by the numbers of variables included. The larger the number of variables and output states, the larger the number of required iterations.

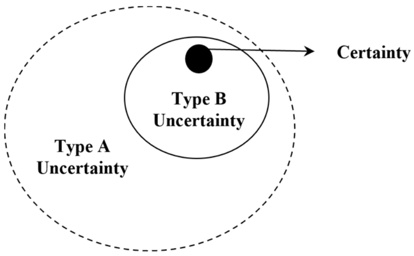
Uncertainty

"Uncertainty must be taken in a sense radically distinct from the familiar notion of risk, from which it has never been properly separated " is noted by Knight (1964 [1921], p. 19). The distinction is drawn along the availability of quantifiable information. Decisions whose consequences 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. *Uncertainty* in situations in contrast, means non-measurability or non-calculability in an empirical sense. While risk can actually be reduced by a priori calculation or empirical estimation, uncertainty can only be managed by judgment and the formation of experience. In consequence is uncertainty, unlike risk, not insurable (Knight 1964 [1921]).

Knightian Uncertainty is the 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 and Stuart 2008, p. 530) and hence forms the starting point for the application of effectuation in managerial decision making (Sarasvathy and Kotha 2001). Nevertheless, management research operationalizes the concept of uncertainty inconsistently, not generally as Knight understands it, and sometimes imprecisely. Basically, the definitional range extends from ignorance of information over a lack of information to the impossibility of having information and data (Packard et al. 2017). Such variance in the understanding of the term points to authors who equate uncertainty with *isotropy*. For them perfect formal calculability exists on one side and perfect incalculable, not predictable situations on the other side. Definitions cover aspects 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 and Venkataraman 2010, 252f.) or uncertainty defined as "[...] situation in which the missing information is yet to be created [...]" (Kuechle et al. 2016, p. 46) refer to the impossibility of recognizing future outcomes and much less being able to take them into account. This paper adopts to and discusses such a perspective at the appropriate point introducing the separate term isotropy (see chapter Isotropy). Knight also understands uncertainty close to isotropy, but less radical, when he implicitly states that uncertainty is an objective problem, which can only be tackled 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." (Knight, 1921, p. 265). While such a definition integrates isotropy in the sense of not knowing or not being able to foresee, it also points to a partially possible control or treatment or management of uncertainty through the collection of data and information. What is problematic about the Knightian understanding of uncertainty is that it leaves open a broad epistemological spectrum to the formalistic concept of risk. On the one hand, there are decision situations and events that can be calculated, and on the other hand, there are decision situations and outcomes that cannot even be predicted.

Against the background of such challenges, later authors stick only partly 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 to generate 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 outcomes of decisions or because of poor understanding of causal relationships (Downey and Slocum 1975). A moderate understanding of uncertainty is based primarily on the assumption that some relationships between variables and outcomes are not yet or cannot be investigated or manifested formal probabilistically. Hence, March (1994) suggest a more nuanced understanding of uncertainty by resolving the often synonymously used terms uncertainty, radical uncertainty and Knightian uncertainty. The distinction includes a moderate definition of uncertainty and a distinction from a radical or Knightian understanding. Knightian uncertainty is equal to the contingency level of ambiguity. Although ambiguity is somewhat related to uncertainty in the moderate sense, it differs because it is based on a general lack of information. Uncertainty however has its origin in a temporarily limited understanding of information. *Uncertainty in the narrow sense (i.n.s.)* is thus based on the assumption "[...] there is a real world that is imperfectly understood" (March 1994, p. 178). The distinction made between the moderate concept of uncertainty, ambiguity (Knightian uncertainty) and isotropy (radical uncertainty) is also reflected by questions about the objects of inquiry in the context of uncertainty. Is the environment uncertain? Are decision makers uncertain? Or are both uncertain? Isotropy/ radical uncertainty and to some extent ambiguity (Knightian uncertainty) assume uncertainty to be originated outside the decision maker. This type of uncertainty, also referred to as type A, is characterized by a stochastic variability of the environment (Campos et al. 2007), of probabilities, outcomes and relationships that are not identifiable or foreseeable ex ante (Miller 2012). Future states and outcomes are incompletely or not known at all, their probabilities of occurrence are therefore not calculable or only calculable to a limited extent, and it is always uncertain what will come next (succession of outcome-related variables) (Hoffman and Hammonds 1994). Type A uncertainty is therefore considered to be irreducible in a planned manner, for example, through deliberate experimentation. Besides this, Type B uncertainty exists. In comparison its origin is rooted in the subjective inadequate processing capacities of the decision maker. Type B uncertainty, also called epistemic uncertainty, arises from knowledge deficits, scientific ignorance, or simply non-observability (Campos et al. 2007).[2]

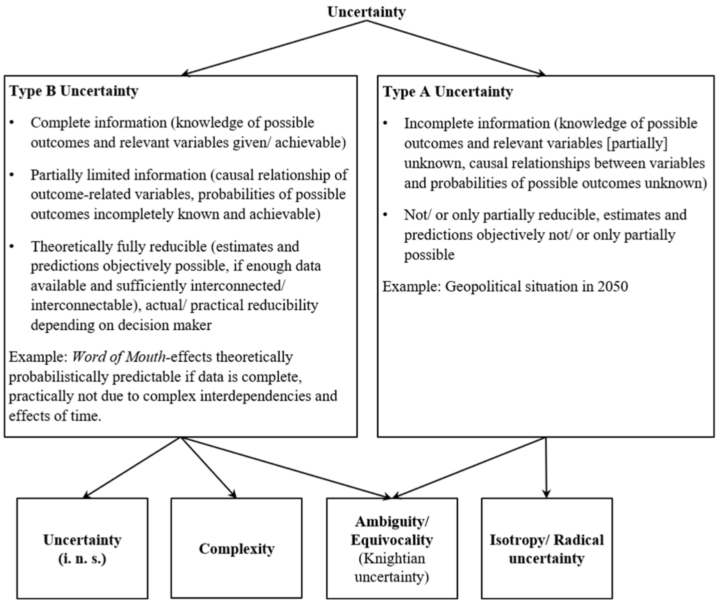
Type B uncertainties are typically residual uncertainties that arise in predictions based on opinions of experts or logical-deductive methods of cognition. Thus, they are not necessarily unresolvable. They are (theoretically) reducible by expanding systemic processing capacities (larger numbers of cases, more sensitive measurement methods, learning, improvement of indicators, investment of time and resources in experiments), since an approximation of complete information in a situation (although not quantifiable) prevails or is attainable. Practically, however, can distinct causal relationships or successions of outcome-related variables become validated probabilistically only to a limited extent. The basic distinction between type A and type B uncertainties allows subsequently different relations of both types to each other. If there is type A uncertainty, also type B uncertainty is necessarily prevalent since decision makers are unable to subjectively incorporate more information than is objectively available. The existence of type B uncertainty means that information about variables and regularities is already available, but these cannot (yet) be reduced to certainty or risk. The hierarchy of the major uncertainty types A and B are shown in **Picture 2**. Subsumed under certainty, the already described contingency level risk is also considered.



Picture 2: Relationships between types of major uncertainty
Source: Own depiction

The so far developed assumptions of different levels of contingency among uncertainty can be found in **Picture** 3. Besides isotropy/ radical uncertainty, that are assigned to type A and the subdivision of the type B uncertainty into uncertainty (i.n.s.) and complexity (see chapter **Error! Reference source not found.**), ambiguity/ equivocality (Knightian uncertainty) is located between the two types. Uncertainty type A describes a lack of information, uncertainty type B describes the lack of ability or possibility in dealing with available information. Uncertainty (i.n.s.) differs from the formalistic concept of risk by its probabilistic limitations since forecasts about future outcomes cannot (yet) be calculated beyond doubt. Nevertheless, in decision-making situations of uncertainty (i.n.s.), experience-based and experience-supported predictions of future outcomes are possible to a certain degree of certainty. The chosen understanding of uncertainty (i.n.s.) thus fills part of the space between radical uncertainty and calculable risk. Uncertainty (i.n.s.) is similar to the concept of risk applied in social sciences as it allows recourse to experience for estimating future outcomes. Theoretically, therefore, decision situations are reducible from uncertainty (i.n.s.) to risk or certainty if decision makers succeed in identifying and handling all relevant variables, interrelationships, probabilities of occurrence, and succession of outcome-related variables. Practically are those undertakings limited by lacks/ progress of time, scarce resources and the multiplicity of variables including their relationships. For example, it is theoretically known that special offers (such as price cuts) increase the quantity of products sold in the short run. However, how long the effect lasts, when and how competitors react to it is unknown or difficult to determine empirically. While it would be possible for empirical forecasting purposes to conduct a long-term and detailed study of the behavioral patterns of certain competitors in response to specific stimuli such as price cuts, an undertaking as such appears rather inefficient in terms of utility from a management perspective. Nevertheless, in the case of uncertainty (i.n.s.) experts can achieve relatively reliable predictions. Either by applying experience-based, subjectively collected a posteriori probability, which serve as a priori probability for estimating future outcomes, or by the option to transfer and abstract historical data to similar decision situations. Dealing with uncertainty (i.n.s.) thus depends to a large extent on the ability of decision makers to make reliable, albeit not fully probabilistic, forecasts by activating, applying and linking existing information. Uncertainty (i.n.s.) is present when all possible outcomes and variables, including their characteristics, are known, but the causal relationships, succession and probabilities of the outcomes are not yet fully deduced or cannot be fully deduced.

[2] Other authors (i.e. Sutcliffe and Zaheer 1998) also distinguish between *primary uncertainty* and *secondary uncertainty*, which is equivalent to Type A and Type B uncertainty.



Picture 3: Differences between major uncertainty types and further differentiation into different levels of contingency
Source: Own depiction

Complexity

A long cybernetic research tradition deals with the *complexity* of knowledge structures within systems and organizations. This of course spills over to management research if management of complexity becomes an USP in dynamic environments (Teece 2007, 2012). Especially the individual perception of complexity has markable influence on the application of decision-making strategies such as causation or effectuation in order to execute decision making, among other things (Mathiaszyk 2017). Complexity thereby has two main origins: detail complexity and dynamic complexity (Townsend et al. 2018). Detail complexity, similar to a formal understanding, refers to the number of considered variables. Dynamic complexity arises from possible interactions and interdependencies of the involved variables. The more variables and the more interdependencies, the higher the degree complexity. A concept that is closely related to complexity is emergence. Emergence represents a social, psychological, or physical phenomenon and ordering principle, that refers to a change of state with new qualities (i.e. the whole is more than the sum of its parts based). Complex systems do not behave linearly, but have the property of being able to form new structures based on the interaction of their elements. A specific property of emergence hence is that an observed phenomenon cannot be concluded directly from the properties of the underlying variables. The nonlinearity of complex systems has come into particular focus as organizational success factors do not appear to follow a linear distribution, but rather an exponential one (success multiplies according to Matthew effect) (Crawford et al. 2015). When decision makers face complexity, attribution difficulties arise. They face the challenge of competing in a complex environment because on the one hand they need to identify relevant factors and variables that may influence their actions and on the other hand they need to know and estimate the interaction effects 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 (Clarysse et al. 2011, p. 140) as well as "[...] the number of opportunity contingencies that must (be) addressed successfully" (Davis et al. 2009, p. 420).

In line with the introduced knowledge dimensions to define levels of contingency, complexity means that possible outcomes and variables are or can be known to decision makers. In case outcomes or variables laying beyond recognizability ambiguity would be present. Complexity arises from the number of included variables, their interactions, and emergent interdependencies. To decision makers are sequences and causal relationships between variables partially but not entirely clear as various interactions may have similar outcomes. Hence, formal probabilities for outcomes can hardly become concluded not least due to often low number of empirical measurable and comparable cases. However, complexity remains an issue of emergence not of fulguration (according to Lorenz 1975) and can be solved by identifying, selecting and understanding relationships between relevant variables. Decision makers need to increase their internal complexity in order to handle external complexity (Crawford et al. 2015). Or in other words: complexity can only be solve by complexity (Ashby 1956; Beer 1994 [1966]).

Ambiguity/ Equivocality

Also, *ambiguity* plays a central role in management research as well as in the study of decisions making in business and organizational theory (Townsend et al., 2018, p. 671). Some authors understand ambiguity as a decision-making environment in which decision makers have knowledge about possible outcomes of their decision, but it is not possible for them to specify their probabilities (Holm et al. 2013). Others declare ambiguity to be a “[...] problem of interpretation because it results from a lack of understanding and/ or consensus regarding the applicability of available knowledge” (Rindova et al. 2010, p. 1477). Both perspectives limit ambiguity to a subjective knowledge problem. On the other hands is ambiguity understood synonymous to isotropy/ radical uncertainty (Fox and Tversky 1995), which rather aims at an objective knowledge problem. In the following, ambiguity will be developed as bipartite concept containing objective and subjective limitations of knowledge. That means ambiguity is characterized by elements that subjectively may not be known and elements that are objectively unknown and hence subjectively cannot be known.

From difficulties in predicting results of repeating identical behavioral experiments Ellsberg (1961) concluded that besides uncertainty and risk, ambiguity must be a distinct problematic category within decision theory. Ambiguity depends on amount, type, reliability and clearness of available information as well as on the confidence of decision makers to conclude probabilities for outcomes. Ambiguity thus considers to what is also referred to in scientific discourse as the impossibility of sensemaking. In specific scenarios, decision makers fail to differentiate signals from the noise in their environment (Weick 1995) and 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 reflect that although in ambiguity there is some information available, there is always also a yet marked space of no information.

Ambiguity is also equated with equivocality. By definition, equivocality arises from the existence of multiple meanings or interpretations toward an object of observation (Daft and Macintosh 1981). Based on that, 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 et al. 2011, p. 553). Hence 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 and Weick 1984, p. 291).

The delineation of ambiguity/equivalence from complexity and isotropy/ radical uncertainty is drawn along objectively available knowledge. Decision situations characterized by ambiguity/ equivocality are to be placed between the major uncertainty types A and B. Ambiguity/ equivocality is present if possible outcomes and relevant variables are not fully known because they cannot be fully known, yet. This is due to unknown relevant variables, indifference towards the relevance of known variables, their probabilities, successions and causal relationships (Davis et al. 2009; Ellsberg 1961). Ambiguity/ equivocality differs from uncertainty (i.n.s.) in that the former is not based on the imperfection of knowledge about causal relationships between means and ends, but on the impossibility of predicting future outcomes and relevant variables whose qualities are indistinguishable (Garud and van de Ven 1992).

Isotropy/ Radical Uncertainty

Although it has already been referred to it several times, the contingency level of *isotropy*/ *radical uncertainty* shall also be briefly described. Isotropy/ radical uncertainty applies to decision situations, outcomes and variables which are still unknown or undetermined in society (objectively) as a whole and for which therefore no future predictions can be made. Isotropy/ radical uncertainty concerns objects of knowledge that are neither present nor foreseeable (Schneider 1997). Outcomes of isotropy/ radical uncertainty are random and cannot be predicted based on the current states of knowledge. The same applies to probability of their occurrence because inherent relevant variables, their causal relationships and internal processes (succession of relevant variables) are not known. Outcomes of isotropy/ radical uncertainty are not uncommonly single events, through which knowledge about interrelationships etc. can only become generated retrospectively (sensemaking).

Isotropy cannot be resolved by intentional system-immanent emergence, because this would require knowledge about a certain number of variables, dependencies and correlations as a starting point for a target definition (e.g. by research). Instead, isotropy/ radical uncertainty is based on the fact “[...] 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). Resolving isotropy/ radical uncertainty only happens through evolutionary leaps (fulgurations). Practically, dealing with isotropy/ radical uncertainty[3] can be observed regarding partnership heuristics of effectuation. *Crazy quilt* aims at indeterminate sensemaking and is based on flexible, arbitrary partnerships. Decision makers interact with business partners who are close to them, known to them, willing to collaborate and available. The purpose of engaging in partnerships is not predefined and emerges from the interaction. Similar to complexity can isotropy/ radical uncertainty only be challenged by isotropy/ radical uncertainty (Townsend et al. 2018). Random options for random solutions must be generated; with indeterminable outcomes.

[3] Some would say hoping for serendipity.

AGGREGATED CONTINGENCY-BASED FRAMEWORK

Error! Reference source not found. aggregates the discussed degrees of contingency. The identified levels of contingency differ based on available knowledge of possible outcomes and relevant variables, knowledge of their probabilities, knowledge of succession of outcome-related variables and knowledge of causal relationship of outcome-related variables/ distinctiveness of all variables. The spectrum of the contingency framework is bounded on the left by the contingence-levels certainty and risk. In certain situations, assured knowledge about all possible outcomes and variables, along with their probabilities of successions of occurrence and interrelationships are present. Causal relationships are unambiguous, and outcomes are calculable and insurable. Certainty and risk differ in terms of that in the case of the latter, the immediate next event is unpredictable.

Uncertainty (i.n.s.) and complexity both assume that experience-based certain predictions are possible, but that these are not yet fully revealed in the context of involved variable variations. I.e. the ingredients for the cake are already procured, but the recipe is missing. Possible future outcomes and constituent variables are largely known, but it is not yet empirically possible to trace causal relationships and effects of all variables beyond doubt or to prove them in the stochastic sense. In the case of complexity, this is aggravated by the fact that too many variables with unknown causal relations have to be considered.

Ambiguity/ equivocality represent a level of contingency in which data is more or less missing. Compared to uncertainty (i.n.s.) and complexity, where there is imperfect knowledge about causal relations between variables and outcomes, ambiguity/ equivocality occurs when decision makers do not know which outcomes can occur or which relevance variables (weight) within causal relationships have. Challenges in reducing this level of contingency arise mainly from the fact that the unknown is unknown. Decision makers do not know what is missing and therefore can only build incomplete causal chains: “[...] no certain answers exist and perhaps the right questions have yet to be formulated” (Daft et al. 1987, p. 359).

Isotropy/ radical uncertainty represent the right pole of the contingency framework. The state is characterized by not only incomplete knowledge about possible outcomes and relevant variables, but also by incomplete knowledge about their existence. Outcomes have no dominant probabilities, everything is equally possible (or not) (chaos), and beyond an existing “lack of clarity” for decision makers “it is difficult to interpret or distinguish opportunities” (Davis et al. 2009, p. 424).

Table 1: Contingency-based framework: Increasing levels of contingency (from left to right) depending on available knowledge qualities

Degree of (Un)Certainty→ Criterion↓	Certainty	Risk	Uncertainty (i.n.s)	Complexity	Ambiguity/ Equivocality	Isotropy/ Radical Uncertainty
Knowledge of all possible outcomes and relevant variables	Given	Given	Given	Given	Incomplete	Missing
Knowledge of probability of all possible outcomes und variables	Given	Given	Incomplete	Incomplete	Missing	Missing
Knowledge of succession of event-related variables	Given	Given	Incomplete	Incomplete	Missing	Missing
Knowledge of causal relationship of outcome-related variables/ distinctiveness of all variables	Given	Incomplete	Incomplete	Missing	Missing	Missing
Objective/ subjective insurable	Given	Given	Yes (, but depending on possibility of empirical validation, sufficient N or based on educated guesses)	Yes (, but depending on possibility of empirical validation, sufficient N or based on educated guesses)	Missing	Missing
Symbolic expression (exemplified)	e.g.: a,a,a,a,a,a,a,…	e.g.: a,b,a,b,a,b,a,b,a,b,…	a+b→c?	e.g.: a+b→c? AND ALSO d+e→c?	(a+b)*c*0→d AND ALSO (e+f)*g*0→d II N of 0? "0"=unknown outcome/ variable	a,b,a,b,(c),(a,b,a,b) OR 000000 (subsequence of unknown outcomes/ relationships/ variables)
Example	"Death and taxes"	Flipping a coin	Competing in a pitch with unknown N of competitors	Development of American declaration of independence in 1787	Consequences of artificial intelligence	Fortuity, rise of Facebook, discovery of ultraviolet light/ Higgs-Boson
Major (Un)Certainty Type	Certainty		Type B		Type A (depending on degree of isotropy)	Type A

Source: own compilation

IMPLICATIONS AND CONCLUSION

The development and consolidation of the presented framework serves as microfoundation for research on decision-making strategies (i.e. effectuation, causation), their prerequisites (i.e. configuration, presence and availability of knowledge) and appropriateness in terms of efficiency. Decision-making theory has developed several strategic approaches to deal with contingency in order to enable and reason decision making (Chandler et al. 2011; Dew et al. 2009; Sarasvathy 2001). I.e. causation focuses its attention "on the predictable aspects of an uncertain future" whereas effectuation focuses "on the controllable aspects of an unpredictable future" (Sarasvathy 2001, p. 251). Those approaches are heavily discussed as assumptions about their configuration appear random and overlapping (Arend et al. 2015; Grégoire and Cherchem 2020; Read et al. 2016). The presented framework may help decision-making situations to different levels of contingency. Organizations can control for subjectively present and objectively available knowledge to evaluate decision-making strategies in order to reduce contingency in decision making. Further research should aim at investigating more on knowledge types within levels of contingency (e.g. declarative/ accumulated knowledge, procedural/ structural knowledge, conceptual knowledge) and match those with decision-making strategies (including but also beyond the most commonly used). This would foster a better understanding about situation-specific decision-making strategies and help organizations choose strategies to deliberately reduce contingency in decision-making situations.

Implications and Further Research

Further research should focus on decision-making paradigms (algorithms, causation, effectuation, bricolage, improvisation, trial & error)[4] that deal with contingency. In order to make those applicable they require revision and clear differentiation as concepts are constructed in overlapping manner due to incomplete recognition in empirical researches (i.e. any occurrence of decision-making strategy beyond causation is declared to be effectuation although it is not distinguished from trial & error or other paradigms). After revision and differentiation of the concepts their capacities to reduce contingency requires investigation. An appropriate research avenue would question how far do specific decision-making strategies contribute to the reduction of contingency in order to efficiently enable reliable decisions? The answer requires an alignment between variations of decision-making paradigms (including their inherent types of knowledge, its transformation and transferability) and their assignment to different levels of contingency. An interesting research case, although not mainly managerial, would be the investigation of knowledge generation among scholars within the SARS-CoV-2-pandemic. At the beginning of 2020, German researchers hardly knew anything about the virus regarding transmission (aerosol vs. smear infection), temperature resistance or the effects of instruments for prevention. By 2022 researchers were able to forecast infections and incidences over 6 months in advance with almost no deviation, including variations of instrumental scenarios. The case indicates an archetypical evolution of knowledge worth investigating.

Contribution to Decision Making Theory

Differentiations within the original concept of uncertainty suits for outlining efficient decision making. The presented concepts show that different levels of contingency can be subsumed under the umbrella-term uncertainty, whereby challenges result from dealing with the synonymous use and lacking differentiation. Uncertainty can exist as two major types (type A and type B uncertainty), and its classification generally results from the relationships between information or data completeness and incompleteness. Type A uncertainty is understood an objective problem, while type B uncertainty is subject to the decision maker only. The distinction is important when it comes to measuring perceptions of uncertainty in empirical studies, since measurement results depend on the units of inquiry (respondents) as well as the objects of inquiry. Depending on own expertise decision makers update more or less limited amounts of information from their environment and coordinate their behavior on this basis. This is standard in cases of (perceived) imperfect information, which decision makers often encounter by means of heuristics (i.e. Trial & Error) without recognizing or collecting the maximal possible amount of information before acting (Busenitz and Barney 1997; McMullen and Kier 2016). Thus, from a subjective perspective, situations may be assigned to higher levels of contingency although objective information about outcomes, relevant variables, probabilities and causal relationships might (objectively) be available. A better understanding of the objective contingency of specific decision situations enables decision makers to select best suitable strategies to efficient decision making. In conclusion the following steps are suggested, to identify levels of contingency and conclude efficient strategies to reduce contingency.

1. Aiming at objective classification of a decision-making situation, exclusivity of the decision-making problem must be questioned: Is the problem objectively and/ or subjectively given? Are objective information/ solutions available (i.e.: expert knowledge, market research approaches)?
2. If gaps of information are identified on subjective level but information would be objectively available, which and how can the gap be bridged (i.e. own research, expertise from factor markets, trial & error, effectuation)? This reflects the efficiency of decision making as either choice of decision-making requires resources.

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[4] See the conceptual works of Rogers, JR. 1987; Gigerenzer 2022; Chandler et al. 2011; Sarasvathy 2008; Hauser et al. 2020; Duymedjian and Rüling 2010; Fisher 2012; Archer et al. 2009.

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