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**UNCERTAINTY TYPES AND TRANSITIONS IN THE
ENTREPRENEURIAL PROCESS**

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Abstract

While judgment has hitherto typically been viewed as a discrete decision process, we propose that it be conceptualized instead as a continuous and dynamic process of reassessment and revision. Adopting this approach, we revisit the nature of entrepreneurial decision-making under uncertainty. We begin with a novel typology of uncertainty that defines and delineates different types of uncertain contexts. We then examine the nature of decision-making within these distinct contexts, highlighting differences in how entrepreneurs make decisions within different types of uncertainty. We build these insights into a theory of the entrepreneurial process that highlights the transitory nature of uncertainty as entrepreneurs make certain judgments and revise those judgments over time. We discuss how uncertainty transitions throughout the judgment process, how the judgment process continues dynamically even after a judgment is made, and how the nature of uncertainty shifts over time due to endogenous and exogenous change.

1. INTRODUCTION

“The image of a decision maker standing at a choice point like a fork in a road and choosing one direction or the other is probably much less appropriate for major everyday decisions than the image of a boat navigating a rough sea with a sequence of many embedded choices and decisions to maintain a meandering course toward the ultimate goal.” — Hastie (2001, p. 665)

Decision making under uncertainty is fundamental to the entrepreneurial process. Firm founders and funders judge what outcomes are feasible, which investments should be made, and whether to move forward with a venture. These are often viewed as *discrete* or *static* decisions, “forks in the road” to which the entrepreneur’s fate is tied (Edwards 1961; Hogarth 1981). We challenge this view and suggest that entrepreneurial judgment be viewed instead as a continuous and dynamic process (cf. McMullen and Dimov 2013, McMullen 2015). Over time, entrepreneurs face different uncertainties as decisions are made, new information is obtained, and the entrepreneur or environment changes. As a result, entrepreneurial judgments are regularly revisited, renewed, and revised. Here we explore this dynamic entrepreneurial process and the uncertainties that contextualize it. We do so by unpacking the nature of uncertainty, offering a novel typology of uncertainties, and applying this classification scheme to the entrepreneurial process as judgments are made and different uncertainties are faced.

Most decision-making research focuses on discrete, one-time decisions (Edwards 1961; Hastie 2001; Hogarth 1981). This is particularly so with high-impact decisions such as consumer purchases (Ariely 2009; Schwartz 2004) and new venture creation (Choi and Shepherd 2004; Dew et al. 2009b). However, many decision contexts are *continuous* and *ongoing* (Hastie 2001). We develop a new framework accounting for the continuous and recursive nature of entrepreneurial judgment. Such a framework is critical for understanding the nature of the full range of entrepreneurial decision making, both discrete and continuous.

The entrepreneurship literature has elided important differences between discrete and continuous types of decisions. For example, a recent review highlights the neglect of time in research on the entrepreneurial decision process (Shepherd et al. 2015). Of course, continuous judgments under uncertainty are

difficult to study because each sequence may be unique, while static decisions can often be replicated or even simulated. But thinking systematically about continuity is critical because entrepreneurship is a dynamic and evolutionary process (Austin et al. 2012; Dimov 2011; McMullen and Dimov 2013), and such dynamism plays a relevant and unavoidable role in entrepreneurial decision making.

In developing our theory, we build upon key insights from the literatures on dynamic decision making (e.g. Brehmer 1992; Edwards 1962) and control theory (Carver and Scheier 1981; Klein 1989). These allow for sequential decisions, feedback, and decision interdependence as well as dynamic environmental conditions. Adopting these (realistic) assumptions allows researchers to explore how individuals make adaptive judgments over time, how feedback and learning loops influence the process, and how the judgment process changes with conditions (e.g. Gonzalez et al. 2003; Smith 2014). However, the dynamic decision-making literature assumes a broad and universal conception of uncertainty and relies on formal models of Bayesian learning. As a result, dynamic decision making, like other formal decision theories, tends to ignore important contextual and individual differences that influence judgment.

To apply a more general notion of continuous and dynamic decision making to the full range of entrepreneurial decisions, we first explore the nature of uncertainty, extrapolating key insights from set theory (Zermelo 1908) and Shackle's (1949, 1961) notion of *potential surprise*. This leads to a novel classification scheme for different types of perceived uncertainty. We extend Knight's (1921) seminal distinction between probabilistic *risk* and non-probabilistic *uncertainty* in explaining how or why certain contexts are probabilistic or not. Building on Shackle's (1949) observation that, for any decision, decision makers must self-populate a set of options and a set of possible outcomes—i.e., potential means and ends are endogenous—we postulate that the nature of uncertainty depends on the “openness” or “closedness” of these sets, as perceived by the decision maker. Accordingly, we develop a typology of uncertainty that includes novel concepts of *creative uncertainty* and *absolute uncertainty*, relating them to the more familiar categories of *risk*, *ambiguity*, and *environmental uncertainty*. We contrast this framework with other prominent classification schemes (e.g. Milliken 1987; Spender 1989). While these well-known schemes

distinguish uncertainty types based on what specific information is unknown, we follow Knight in distinguishing types of uncertainty based on whether and why probabilities can be estimated.

A better notion of uncertainty lets us explore how entrepreneurs make decisions in particular uncertain contexts and how these contexts change throughout the entrepreneurial process. Applying insights from dynamic decision making and control theory, we conceptualize entrepreneurship as a series of transitions from one type of perceived uncertainty, and the form of judgment that accompanies it, to another. Extending our view to less controlled and more realistic uncertainty contexts, we gain important insights into how entrepreneurial judgments are made as entrepreneurial actions and outcomes unfold over time.

We define judgmental decision making in terms of *reasoned action*, the purposeful (though not necessarily “rational”) selection of a specific course of action according to the goals, beliefs, and expectations of the decision maker (Knight 1921; Mises 1949).¹ Decision includes not only *choice* among given options and outcomes, but also *judgment* about what options and outcomes are feasible. Action (including “non-action” such as resting or deferring a decision) is the necessary and immediate result of some decision. Only instinctual or reflexive (i.e. non-reasoned) actions can occur without decision. Because entrepreneurship is reasoned action in uncertainty, we focus our attention on perceived uncertainty to understand the reasoning of entrepreneurial judgment and the subsequent actions taken as its result. Entrepreneurial outcomes, on the other hand, depend not only on subjective perceptions of the entrepreneur, but also on what Knight (1921, p. 232) calls “true” uncertainty, the objective conditions of the environment and how these conditions interact with the entrepreneur’s perceptions and actions.

Our dimensionalization and contextualization of the uncertainties behind reasoned action proceeds as follows. First, we offer a new classification scheme for types of uncertainty that are often conflated in the literature. Second, we describe the nature of uncertainty and its various types, clarifying how, why, and in what ways different decision contexts are uncertain. Third, we expand on entrepreneurial decision-making research, exploring the cognitive mechanisms entrepreneurs use to make judgments given

¹ While we reference the “decision maker” in the singular, our general approach is meant to apply to decision-making with any number of persons.

their limited capacity to deal with unpredictability, and we illustrate how this decision process may vary according to the nature of uncertainty that the entrepreneur perceives. Fourth, we offer an initial development of a more general theory of the entrepreneurial decision process based on our typology, focusing on the uncertainties involved in early-stage entrepreneurship, the strategies entrepreneurs use to resolve that uncertainty, and the implications of dynamic and recursive decision making in entrepreneurship. The result is a novel framework for better understanding uncertainty and its implications for entrepreneurial behavior over time.

2. DIMENSIONS OF UNCERTAINTY

Much contemporary social science rests on the assumption of rational choice (and our apparent departures from it). “Rationality” assumes that options and outcomes are known, from which an optimal choice is made (Miller 2007; see also von Neumann and Morgenstern 1944; Savage 1954; Kahneman and Tversky 1979; Ariely 2009). Clearly, this assumption is more normative than descriptive. Decision is a cognitive process, meaning that actors make selections from the thoughts and knowledge available at the point of decision (Shackle 1961). Judgments and choices are made by “boundedly rational” decision makers who have incomplete and sometimes incorrect knowledge. While judgments are informed by objective reality, they rest on subjective and often tacit interpretations, and *ex ante* cannot be considered “correct” or “incorrect” (Foss and Klein 2012; Mises 1949; Simon 1979).

Knight (1921) argued that business decision making is based not on known probabilities, but on intuition, understanding, or gut feeling—what Knight called judgment. This is different from prospect theory and similar approaches that treat decision makers as acting upon probabilities, albeit subjectively determined and subsequently updated (Savage 1954). Subjective probability theory, while convenient for modeling purposes, is probably not descriptively accurate; Harrison (1977), for example, found that business managers broadly rejected the probability-based decision framework as overly simplistic and unrealistic, preferring contingency-based decision models (cf. Mintzberg et al. 1976; ogilvie 1998). The effectuation literature (Dew et al. 2009a; Sarasvathy 2001, 2008) argues that expert entrepreneurs tend to reject

attempts to predict the future, but instead seek to shape future outcomes through effective control of resources (Ucbasaran 2008). Subjective probability theories are thus ill-equipped to deal with the types of judgments with which we are primarily concerned.

Another way to express Knight's position is that entrepreneurial processes are non-ergodic. "By definition, an ergodic stochastic process simply means that averages calculated from past observations cannot be persistently different from the time average of future outcomes" (Davidson 1991: 132). The world is not ergodic; human action and innovation constantly shift the basic structures within which decisions and actions are made (North 2005). New ventures, for example, alter the context in which they occur such that replication is impossible (Shackle 1949). Instead of reliable expectations or probabilities, the entrepreneur faces Knightian uncertainty and must make judgments based on imagined outcomes of future possibilities (Shackle 1961).

Extending the distinction between risk and uncertainty, we find additional insight in set theory, describing scenarios in terms of option and outcome sets that can be open or closed (Zermelo 1908).² We can relate these insights to extant schemes such as the distinction between external (exogenous) and internal (endogenous) uncertainty (Tushman and Nadler 1978; Folta 1998; Galbraith 1973).

In the theory of potential surprise (Shackle, 1949, 1961), decisions are comprised of two sets: a set of available options, commonly termed the "retrieval" or "consideration" set, and a set of possible outcomes (Roberts and Lattin 1991; Shocker et al. 1991; Arrow 1951). Decision is the selection of some option from the consideration set by assessing its pairing with some subset of possible outcomes. Decision makers select the option, or course of action, they believe is most likely to lead to a preferred outcome, least likely to lead to some unwanted outcome, or some combination of these. In this framework a probability can only exist if both sets are closed (Zermelo 1908; Cohen 1966). Because most real-world decisions have open sets, Shackle (1949, 1961) called for replacing the concept of probability with the more

² More accurately, these sets may be described as *infinite* and *finite* rather than *open* and *closed*, respectively. A set is considered to be *finite* if it is empty or if it consists of exactly some finite number (integer) of elements; otherwise it is said to be *infinite* (Lipschutz and Schiller 2012). However, we keep with the more familiar terms "open" and "closed" for clarity and connection to previous literature.

unremarkable, yet appropriate, term *possibility*.

When the number of possible outcomes is uncountable, we cannot assign a numeric probability to any outcome because it cannot be compared to all alternatives (Shackle 1972; Lachmann 1976). Similarly, if the set of options is open—option sets are open as long as innovation is possible—one option cannot be compared to all (infinite) possibilities. A probability distribution can exist only for those options that have a closed set of possible outcomes. Many options, including those that remain unknown, have indefinite outcomes. Thus, probability-based decision fails where these sets are open.

In summary, the foundation of Knightian uncertainty—the reasons why probabilities do not exist for certain decisions—can be understood in terms of the nature of these option and outcome sets. Specifically, uncertainties exist only when one or both sets are perceived as open. We turn next to these sets in describing and delineating types of uncertainty.

2.1 A Typology of Uncertainty

We propose a typology of uncertainty that delineates types of Knightian uncertainty and offers insight into the nature of these types. We have identified the *set of options* and the *set of outcomes*—whether they are open or closed—as key distinguishing elements. We distinguish five specific uncertainty types within four general domains. Following conventional terminology as much as possible, we call these domains 1) *risk* and *ambiguity*, 2) *environmental uncertainty*, 3) *creative uncertainty*, and 4) *absolute uncertainty*.

Early studies of decision making under uncertainty focused on Bayesian learning (subjective expected utility; Savage 1954), game theory (von Neumann and Morgenstern 1944), and cognitive and behavioral science (e.g. prospect theory; Kahneman and Tversky 1979). Arrow (1951, p. 404) described this research landscape as comprising “a set of conceivable actions which an individual could take, each of which leads to certain consequences”—that is, decisions where option and outcome sets are *closed*. But these approaches omit important contexts in which these sets are open.

In management research, attempts to classify and understand uncertainty have generally focused on the locus of uncertainty, i.e. what information is missing. For example, “behavioral uncertainty” refers

to uncertainty about how individuals will act. Our approach extends and interprets these classifications at a more basic level. While these approaches describe *where* the uncertainty occurs, we seek to describe the basic nature of that uncertainty. In other words, we seek to describe uncertainty in terms of *why* it is uncertain, i.e. why probabilities are indeterminate.

Milliken's (1987) well-known distinction between state, effect, and response uncertainty can also be elucidated by our framework in explaining *how* and *why* certain environments are perceived to be unpredictable. *State* uncertainty and *effect* uncertainty, for example, both correspond to what we describe as *environmental* uncertainty, derived from the complex and dynamic nature of the environment which causes the set of outcomes to be perceived as open. *Response* uncertainty, or the uncertainty that results from the unknowability of competitors' responses to any chosen course of action, results from an open set of outcomes derived from a competitor's open set of options; because one cannot necessarily know how others will act, one cannot predict how those actions will affect a given outcome.

A more recent and comprehensive typology (Dequech, 2011) incorporates three dimensions: substantive-procedural (Dosi and Egidi 1991), weak-strong (Dequech 1997), and ambiguous-fundamental (Dequech 2000). The substantive-procedural dimension reflects Simon's (1979) distinction between substantive versus procedural rationality—whether the uncertainty derives from a lack of information (substantive) or a lack of computational ability (procedural). The weak-strong dimension reflects Knight's distinction between probabilistic (weak) and non-probabilistic (strong) scenarios. The ambiguous-fundamental dimension distinguishes between stable, finite realities that are merely unknown (ambiguous) and realities subject to non-predetermined structural change as a result of individuals' creative capacity (fundamental). While this approach is close to our own in capturing different types (natures) of uncertainty, and not merely their loci, its dimensions overlap in ways that may produce confusion. It also combines types of uncertainty that may be better understood as distinct (see Table 1).

Our approach takes a more fundamental look at the causes of uncertainty, employing the sets of options and outcomes to delineate different types. By highlighting whether these sets are open or closed, we ascertain *why* particular contexts are uncertain, i.e. why a decision maker cannot determine a single

expected outcome nor assign a probability to multiple option-outcome pairs.

Here the distinction between *true* and *perceived* uncertainty becomes important. Because decisions are based on *perceived* uncertainty, the nature of the option and outcome sets, and thus the type of uncertainty, are subjective and often tacit. In many circumstances, for example, a question may be posed in different ways resulting in different types of uncertainty. The type of uncertainty, as subjectively determined, then results in distinct decision processes. For example, the questions “Should I start a business?” and “Should I start *this* business?” imply different types of uncertainty from which judgment must be made. In the former, the question is resolved through introspective consideration of personal goals and expectations. The latter must be resolved through analytical consideration of the specific risks and rewards, and the entrepreneur’s willingness or ability to bear those risks, associated with a given business proposal. *True* uncertainty is based not on subjective perception, but on the actual nature of the decision, i.e. the complete set of possible options and the (non-)ergodic state of the environment.

For clarity of exposition, we describe uncertain contexts in terms of *true* uncertainty, rather than *perceived* uncertainty, to represent the nature of uncertainty as it normatively should be perceived. Examples for each uncertainty type are also given in terms of true uncertainty (except where explicitly stated). However, decisions are made only from *perceived* uncertainty.

Figure 1 illustrates our taxonomy of uncertainty types. Following Knight (1921), we define *risk* as the ergodic stochastic context in which both the option and outcome sets are closed, and where the relationships between each option and outcome is given by a known probability. Decisions in this domain are choices among specified alternatives, where the decision maker selects from given options according to preferences³ and willingness to bear risk. Games of chance and insurance markets are the best-known examples of risk. Expected utility theory (von Neumann and Morgenstern 1944) deals exclusively with this domain. While we think that few business decisions involve true risk in this sense, we might offer an example of *perceived* risk. A firm may approach management tasks *as if* the severities and probabilities of

³ We follow the Austrian tradition (Rothbard, 1956) and assume that preferences (i.e., ordinal rankings) are given but are tacit and only manifest, or revealed, by action.

various possible outcomes are given. Thus, managers make risk management decisions based on a desire to lower outcome severities and/or outcome probabilities, as they perceive them, in order to reduce the impact estimates of unwanted outcomes.

Insert Figure 1 about here

Ambiguity has been much more broadly used and defined in the various literatures. Economics generally follows Ellsberg's (1961) conception, which, like risk, assumes an ergodic stochastic context with a finite set of options and outcomes, but with unknown probability distributions of possible outcomes. This was exemplified by an urn filled with colored balls, where participants were told the color and total number of balls, but not the ratio of different colored balls. The recognition of ambiguity led economists to adapt the expected utility framework to account for such ignorance (Savage 1954).

Because ambiguity seems to describe the unknown aspect of decisions, it is often conflated with uncertainty (e.g. Camerer and Weber 1992; Hey et al. 2010). We distinguish these, defining ambiguity as the case where options and outcome sets are closed, but the probabilistic relation between them is unknown. For example, consider a firm that is bidding for a contract. The firm does not know how many competitors have also bid, nor can it know specifically what, or to what extent, specific criteria are prioritized in the decision. Assuming the criteria are determined and fixed, the contractor is in a state of ambiguity, where a probability is calculable to an omniscient observer, but is unknown to the contractor, who must make a bid without such data. Our definition of ambiguity, then, is specific, and should not be confused with other familiar notions of ambiguity that signify vagueness (e.g. March 1978).

While economics and the behavioral sciences focus primarily on risky and ambiguous scenarios (which are potentially measurable), strategy and entrepreneurship researchers have become more interested in *environmental uncertainty*, which seems more relevant to business decision making (e.g. Downey and Slocum 1975; Downey et al. 1975; Galbraith 1973; Jauch and Kraft 1986; Milliken 1987; Buchko 1994). We define environmental uncertainty as the situation where the set of options is closed but the set of outcomes is open, leaving decision makers with an indefinite number of possibilities to consider or,

more practically, a set of outcomes that they must populate themselves.

Environmental uncertainty embodies the complexity and dynamism of non-acting factors (Downey et al. 1975), as well as the collective effect of all actors on the environment. The culmination of these is an uncertain environment, in that the outcomes of any chosen course of action cannot be fully predicted because of unknown changes to the environment over time and potential ignorance of the effects of specific actions. Consider, for example, a CEO who evaluates three new product proposals and asks herself: Which proposal should my firm pursue? Because of time and resource constraints she can choose only one, which will then be developed and launched into the marketplace. While the set of options (three proposals) is limited, the possible outcomes (potential reactions of customers, rivals, regulators, and other stakeholders) from each option are unlimited. The CEO must use relevant knowledge, experience, and intuition to imagine how various actors might respond to each product, what other issues might arise, and so forth. Knight explained that this type of uncertainty arises due to the innate uniqueness of the scenario, which inhibits the assignment of Bayesian probabilities to the context.

Creative uncertainty exists at the opposite corner of the typology from environmental uncertainty. Here the set of outcomes is closed and the set of options is open. It is the proverbial block of stone ready for sculpture. A task might be approached with a given or desired outcome but no known solution. For example, a supervisor might assign an employee a task without specifying the means: “I don’t care how you do it, just get it done.” The set of outcomes is thus reduced to two given outcomes, “done” and “not done,” while the set of means for achieving the desired outcome remains open. Of the potentially infinite possible solutions, at least one must be imagined and selected in order to achieve the desired outcome. This uncertainty results, then, from the fungibility of the set of options and the ignorance of possibly superior alternatives. Such uncertainty is the key issue of the “maximizer” who is perpetually concerned that there may be some superior alternative to the options under consideration (Schwartz et al. 2002).

The commissioned sculptor, tasked with recreating a hero of times past, faces creative uncertainty in the project before him. He asks himself the question: Will I successfully sculpt a piece that will satisfy my patron? The relevant outcomes are seen as finite—either he completes the sculpture satisfactorily or

not—but the stone (or marble or clay) remains blank before him, presenting endless possible scenes, poses, expressions, and other artistic licenses by which the task might be completed. While creative solutions generated by innovation will typically vary in effectiveness in achieving a given outcome (e.g. satisfying target consumers), this type of uncertainty is defined by a closed set of outcomes. Where innovation is possible, the set of creative options is bounded only by the number of resources that are available to the innovator. These resource constraints do confine the set of potential options, but do not reduce the quantity of options to anything less than infinity (Penrose 1959; Barzel 1997, Foss et al. 2008).

Finally, what we term *absolute uncertainty* exists where both option and outcome sets are open. A substantial portion of entrepreneurial decision making exists within the realm of this “extreme” uncertainty (Harrison 1977; Shepherd et al. 2015), especially during its initial stages. The entrepreneur applies judgment not only to what consumer needs can be better met, but also to what solutions could better meet them. Consider an individual who, frustrated with some unmet personal need, sets out to resolve it. Perceiving the issue to be prominent, she becomes engrossed in what she perceives as a new opportunity. She asks herself: What solution might I devise to solve this problem, and how valuable could such a solution be? At this point, her uncertainty is absolute. First, she has unlimited possibilities by which she may address the perceived need. Even if the entrepreneur is resource constrained, the possibilities remain endless (Baker and Nelson 2005; Penrose 1959), and are bounded only by the ability of the entrepreneur herself to innovate solutions (Shackle 1961). Second, the possible outcomes are unknown and unknowable, as the specific effects of any course of action, the sequence of external events, the decisions and perceptions of others, and the environmental winds of change cannot generally be predetermined or foreseen. To proceed she must decide whether to commit efforts and resources toward the pursuit of this perceived opportunity, bearing the weight of significant (absolute) uncertainty and not knowing what, when, or how events will play out, how any specific course of action might alter those outcomes, whether superior strategies or solutions may exist, or whether specific solutions are even truly viable.

In summary, the nature of the perceived sets of options and outcomes suggests four distinct domains of uncertainty. We contrast these types of uncertainty with previous taxonomies of uncertainty in

Table 1. Each type has distinct and important implications for a number of key aspects of entrepreneurship theory. In particular, the decision process itself varies in significant ways depending on the differences in the relevant uncertainties. Such differences may have important implications for the entrepreneurial judgment process and how that process evolves over time. We elaborate on these implications in the next sections.

Insert Table 1 about here

3. UNCERTAINTY AND THE DECISION-MAKING PROCESS

While much of rational choice theory (Savage 1954, Ramsey 1931) and behavioral decision theory (Kahneman 2011; Schwartz 2004) assumes decision processes are consistent among and between individuals, we suggest that the selection and use of distinct decision processes depend upon various internal and external factors. Primary among these factors is the perceived nature of the decision itself and the uncertainty that it embodies. While our overall framework is dynamic and recursive (following, e.g., Brehmer 1992 and Edwards 1962), we begin by focusing on short-term, discrete, or static judgments within the dynamic process (Edwards 1961; Hogarth 1981). The dynamic decision process, as we elaborate below, is comprised of many discrete micro-judgments over time as chosen actions are reconsidered and amended. Here we examine these micro-judgments and how they are made within the perceived context of uncertainty. For this we borrow from Shackle's (1949, 1961) theory of potential surprise, showing how modern insights into the decision process can be integrated within Shackle's more comprehensive decision theory.

According to the potential surprise framework, in contrast to rational choice theory, decision makers construct a set of options and a corresponding set of possible outcomes for each conceived option based on experience and imagination (except in those rare cases where options and outcomes are given). Decision makers may choose to refine these sets further by eliminating options or outcomes that are deemed implausible (Roberts and Lattin 1991). The remaining outcomes are judged according to their *possibility* (in contrast to *probability*), with more than one outcome potentially being judged as perfectly

possible. Further consideration is given to the “ascendency,” or particular interest or concern, of certain options or outcomes, the most ascendant typically (but not always) being the perceived best-and worst-case scenarios. Of the remaining options, the most possible and highly ascendant outcomes for each option are weighed, after which an option is chosen according to the individuals’ personal characteristics (e.g. risk aversion) and the degree of “affordable loss” (Dew et al. 2009b; Shackle 1966).

Decisions, in the end, depend on how the decision maker perceives the relevant uncertainties; i.e., the openness or closedness of each set is subjectively determined. Of course, the decisions of other actors, the institutional context, and path dependence may affect the decision maker’s perception. However, we emphasize that these factors are subjectively interpreted in each decision context. Moreover, how a decision is made may depend on decision makers’ awareness of their own ignorance, which is necessary (but not sufficient) for recognizing an open set.⁴

An important implication of this process is that decision sets are populated and judged based on the characteristics of the decision context, including the type of uncertainty in which the decision resides. These factors may result in varied expectations, ascendancies, and, resultantly, decisions. It may be useful, then, to explore the various types of uncertainty with respect to their unique impacts on the decision process. In contrast to the previous section in which we defined each type of uncertainty in terms of its *true* nature, in this section we outline decision processes according to *perceived* uncertainty.

3.1. Choice under Risk/Ambiguity

Decision making under risk has been most thoroughly researched. In situations of risk, the decision process is comparatively straightforward and analytical. While the specific outcome is unknown *a priori*, the likelihood of each outcome is known. Such processes can be reduced to mathematical optimizations. The only subjectivity comes from the individual’s unique preferences and attitude toward risk-taking. There may be differences in expectations of the consequences of each outcome, and in this sense

⁴ A set may also be perceived as closed where the decision maker does not know the corresponding likelihoods of its elements. A novice poker player knows that only certain hands are possible but may not know their likelihoods. Such a possibility is captured within the framework of potential surprise, as each perceived option-outcome pair is assigned a possibility (or subjective probability), whether the set is perceived as open or closed.

relevant experience and information may privilege one decision maker over another. However, most research in this domain examines contexts in which the benefit is presumed to be universal, such as financial gain (e.g. Thaler 1988). Deviations from theoretical expectations, then, are presumed to be irrational (Ariely 2009). We term such decisions *choices*, in which a preferred option is selected.

Under ambiguity, in contrast to risk, subjective factors are more relevant as individuals may possess unique information related to the probabilities of outcomes, as well as distinct abilities and preferences. Those with pertinent information may be able to reduce the context to risk. Those with less information, or who possess weaker analytical capabilities, must fill in the missing information with assumptions or estimations, and may rely on various other contextual factors or heuristics (e.g. Tversky and Kahneman 1973, 1986; Park and Lessig 1981). Alternatively, the decision maker may defer the decision until more information is collected (Dhar 1997). If the decision or event of interest repeats over time, however, experience produces information that can fill in the gaps, and the repeated decisions can, over time, be reduced to choice in risk (e.g. insurable events).

3.2. Judgment under Creative Uncertainty

Under conditions of creative uncertainty, the decision process shifts from comparison of known options to open-ended consideration of possibilities. As with risk and ambiguity, there is a closed set of outcomes in creative uncertainty from which a preferred outcome is selected. However, because the set of options remains open, how the preferred outcome is to be achieved is unknown (Dequech 2006). This set must be populated by the decision maker through the imagination of possibilities. The resulting retrieval set, a finite subset of the exceedingly large or infinite domain, reduces the decision to a cognitively manageable sample (Kardes et al. 1993). Probabilistic relationships between options and outcomes may not be known within this retrieval set. If they are known, the decision reduces to risk, and becomes a process of choice. However, if one or more options have an unknown outcome probability distribution, the decision requires human imagination, intuition, and estimation in a judgment process.

How the set of options is populated, then, becomes critically important. Because the set of options is not given, any solution within this set must be retrieved from known options or created as a new option.

Certainly, greater knowledge or experience will likely produce a wider array of familiar options, but the set is unbounded, allowing creativity to produce never-before-encountered options for consideration (Dequech 2006). Indeed, some studies suggest that knowledge and experience can inhibit creativity because they constrain the consideration set to only familiar options (Bilalić et al. 2008; Dane 2010). The limits to this set are determined only by resource availability and the creative ability of the decision maker to imagine possible solutions to the preferred outcome. Creativity, along with its antecedents, and influencing factors, have been widely studied (e.g. Amabile 1996; Csikszentmihalyi 1997; Sawyer 2012), and we defer to this literature for a more in-depth exploration of this process.

Once the retrieval set is populated and closed, a judgment is made on which of the options is most likely to achieve the preferred outcome (or least likely to result in an undesired outcome) in relation to its possibility. This judgment is based on intuitive and imagined expectations for each option. If no viable solution is found within some reasonable expectation of viability, as subjectively determined, the decision may be deferred for further search (if time allows), or the status quo may be selected.

3.3. Judgment under Environmental Uncertainty

Environmental uncertainty also cannot be reduced to probabilities. While the number of options is constrained, the set of possible outcomes is not, so while the preferred option must be selected from a finite set, forecasting the effects of that selection requires intuition in anticipating possible outcomes.

Because the set of outcomes is open, it must be populated by the decision maker through an imagination of possible scenarios. This imagination occurs as each option is input into the decision maker's cognitive map, or "small world representation" (SWR), of reality (Maitland and Sammartino 2015) and is played out imaginatively to its expected outcome, given assumptions of how the world works. A prudent decision maker will acknowledge their SWR to be limited and account for factors that are less sure by allowing alternative possibilities to play out using different assumptions. Thus, for each option, some array of possible outcomes may be imagined based on prior experience, knowledge, and creative imagination, after which the possibility of each outcome is ranked based on how surprised the decision maker would be were that outcome to occur. Such surprise reflects the intuitive assessment of possibility the decision

maker holds given the view of reality. Furthermore, these imagined outcomes may have greater or lesser “ascendency” for a variety of possible reasons, such as potential impact, past experiences, or psychological issues. Once each outcome is assessed, the process of judgment unfolds as described above.

3.4. Judgment under Absolute Uncertainty

In contexts of absolute uncertainty, both the set of options and the set of outcomes must be subjectively populated. Decision makers often seek to reduce the complexity of this decision context by reducing the consideration set of options and their corresponding outcome possibilities through the elimination of implausible options or undesirable outcomes (Roberts and Lattin 1991; Shackle 1949, 1961; Shocker et al. 1991) and by resolving the uncertainty as much as possible before judgment is made. Collecting and controlling information (Jauch and Kraft 1986; Pacheco-de-Almeida and Zemsky 2012), protecting against undesirable outcomes (e.g. Caves and Porter 1978), maintaining contingency plans and flexible organizing (Galbraith 1973; Milliken 1987), and various other strategies may help resolve or manage this uncertainty. Entrepreneurial action occurs only once uncertainty is sufficiently accounted for according to the subjective assessments and preferences of the entrepreneur (Foss and Klein 2012).⁵

Populating the option and outcome sets can follow two distinct paths, which (following Sarasvathy 2001) we term *causation* and *effectuation*. A causal approach involves first populating the set of desired outcomes, then populating the set of options in response to the preferred outcome, as under creative uncertainty. This is reflected in the typical demand-pull approach to innovation, in which a recognized consumer problem prompts the search for a viable solution. The desired outcome is first decided, after which a secondary judgment must be made from among the option set.

Under an effectual approach to judgment under absolute uncertainty, the decision maker first populates the set of options based on a given or perceived endowment of resources, then populates the set of outcomes, as in environmental uncertainty. Research on effectuation (Dew et al. 2009a; Sarasvathy 2001,

⁵ By “action” here we mean specific, discrete decisions that make up the entrepreneurial process; we do not mean to suggest that the process only takes place after uncertainties are resolved. Rather, we agree with the effectuation literature that the entrepreneurial process is nonlinear, that uncertainties are resolved over time as the results of specific actions are revealed, and so on. See the discussion in the next section, especially section 4.2.

2008; Sarasvathy et al. 2008) suggests that an effectual approach often provides superior results because judging outcomes before considering resource constraints can limit options and lead to less efficient uses of available resources. In our framework, however, causation and effectuation processes may unfold inter-dependently over time; as various options or outcomes are imagined and considered, revisions to the other set may become expedient until a more refined consideration set is achieved and, ultimately, a single option emerges as preferred.

4. UNCERTAINTY AND THE ENTREPRENEURIAL PROCESS

The above uncertainty taxonomy provides new insight into entrepreneurship as a means of resolving uncertainty. Specifically, the entrepreneurial process can be seen as a series of micro-judgments by which entrepreneurs resolve uncertainty, transitioning from one state of uncertainty to another, until uncertainty is sufficiently resolved to make the decision to exploit. As defined above, decision (judgment) is the necessary precursor to action; i.e., individuals act according to their judgment that action will produce some desired effect. While in retrospect some judgments clearly prove superior to others, such outcomes cannot be known *ex ante*.⁶ We thus reject both the normative, rational-actor view and the idea that entrepreneurial profit results from luck rather than superior judgment (though luck can also play a role, as in Austin et al. 2012, Barney 1986).

Instead, outcomes result from the interplay between controllable (endogenous) and uncontrollable (exogenous) factors. Thus, while action is necessarily determined by judgment from perceived uncertainty, outcomes are the result of that action in conjunction with the true uncertainty of the environment resulting from complex interactions between physical and social systems, including the actions of an unknowable number of other actors. Put differently, reality bats last. We do hold that some entrepreneurs may possess superior judgment capabilities than others (Foss and Klein 2012), whether those capabilities be from superior knowledge, intelligence, foresight, or other talents, and this may explain variation in entrepreneurial outcomes (e.g. Elfenbein et al. 2010).

⁶ As Foss and Klein (2015: 591-592) emphasize, judgment per se is distinct from the ordinary language notion of “judgment” as good judgment, i.e., wisdom, prudence, or decision-making skill.

Uncertainty, both perceived and true, changes over time (North 2005). Its nature evolves as decisions are made and actions taken. Such transitions can make an accurate perception of true uncertainty difficult or impossible to attain. However, consideration of the entrepreneurial process suggests patterns in these shifts, as outlined in Figure 2. Note that the following process outline is generalized, and some entrepreneurial processes will not fit perfectly, as each entrepreneur may subjectively perceive a different type of uncertainty from which she begins the process. The dynamic nature of uncertainty is universal, however, and the resulting logic suggests that entrepreneurs adopt shorter-term action plans and reassess and revise those plans frequently as needed.

Insert Figure 2 about here

4.1 Recursion and the Entrepreneurial Judgment Process

Before judging a potential entrepreneurial action, potential outcomes must be assessed in terms of value and viability. This can be especially difficult when assessing novelty, e.g. new innovations, because they originate in conditions of absolute uncertainty. That is, at the point of recognition, the problem (e.g. a consumer need) the entrepreneur wishes to address has a potentially open set of possible solutions, each of which has an unknown and open set of outcomes. Throughout the entrepreneurial process, this absolute uncertainty may become partially and incrementally resolved over time through intermediate judgments and their corresponding specific and intentional actions, and the learning which results from the outcomes of those actions (Edwards 1961). These intermediate judgments then transform the nature of the perceived uncertainty to a simpler form, until the uncertainty becomes a manageable decision between limited options with expected outcomes.

Under absolute uncertainty entrepreneurs can use either causal or effectual reasoning (Sarasvathy 2001). In a causal approach, the entrepreneur first attempts to resolve the absolute uncertainty into creative uncertainty by addressing environmental uncertainty. That is, before the entrepreneur attempts to discover or create a solution to the entrepreneurial problem, she makes an initial judgment regarding the potential value of the opportunity by estimating the social importance of the recognized problem (Choi and

Shepherd 2004; Hsieh et al. 2007; McMullen et al. 2007; Mitchell and Shepherd 2010). If the problem solution is perceived to have a high potential value (i.e., it is a strongly and widely held need), she may judge the potential outcome to be worth further investment of time, energy, and resources in seeking an economic solution. Thus, environmental uncertainty is first resolved in estimating the expected value, in effect closing the outcome set and leaving creative uncertainty to be resolved. The entrepreneur must then focus efforts on the creative resolution of the chosen problem with the resources available (or those that may become available) (Hsieh et al. 2007). This creative process would persist until a satisfactory solution is conceived, the entrepreneur decides no economic solution exists, or conditions change (e.g. resources become depleted) such that the search is abandoned.

Entrepreneurs using effectual reasoning, in contrast, seek to transform absolute into environmental uncertainty by first addressing creative uncertainty. Here, the entrepreneur starts with a given set of resources and capabilities from which she determines possible uses through effectual processes of ideation. This approach permits higher levels of creativity and innovation as the entrepreneur is not constrained by a particular idea or problem to solve but by the resources available (Fisher 2012). This squares with research on creative cognition, which suggests that resource constraints, rather than task constraints, lead to more novel ideas (Finke et al. 1992; Smith et al. 1995). Outside actors such as investors, acquaintances, or consumers may also contribute viable options. After considering possible combinations and applications of available resources and capabilities to generate possible uses, the context changes to environmental uncertainty in which the entrepreneur judges possible outcomes as subjectively and imaginatively determined. The entrepreneur either selects one of these outcomes to pursue or returns to ideation to generate more ideas.

A consideration set of option-outcome pairs is thus repeatedly revised, a process we term *judgment recursion*, with the entrepreneur taking causal or effectual paths until reaching a proposed solution to a perceived problem given the available resources. As certain options are eliminated from consideration, either because the affordable loss is too great, the possible gain is too small or unlikely, or some other factor is of great concern (Shackle, 1949), attention continuously shifts to other options until only

one or a few remain. If more than one option remains, and these are subjectively considered to be approximately equivalent, a judgment must be made to reduce the set to one, which constitutes final entrepreneurial judgment (Foss and Klein 2012; Knight 1921), followed by entrepreneurial action.

While we have focused on innovative entrepreneurship here, this framework applies similarly to imitative entrepreneurship. The imitator benefits from the uncertainty-reducing actions taken previously by incumbent firms, but may reconsider the option set and pursue an alternative solution or avoid the extra uncertainty of such decisions by imitating or incrementally improving accepted designs (Vyas 2005). Thus, potential imitators must make a similar entrepreneurial judgment upon entering the market, which again involves an estimation of potential and expected gains against possible losses.

4.2 Dynamic and Continuous Judgment

While decision making is generally understood as a finite process with a specific outcome, we prefer to see entrepreneurship as a sequential process unfolding over time (McMullen and Dimov 2013). How does our analysis of entrepreneurial judgment as transforming absolute uncertainty into creative or environmental uncertainty apply to sequential decision making?

Once a decision to establish a new venture, make a new investment, or introduce a new product is made, substantial uncertainty remains, and there is considerable scope for further entrepreneurial judgments (Cohen and Levinthal 1990; Hambrick 1982; Zahra and George 2002). Moreover, entrepreneurial decisions are always subject to revision as new information is revealed, cognitive biases are reduced, and judgment ability improves. Thus, entrepreneurial judgment is not static or discrete, but dynamic and continuous, involving experimentation, learning, and selection (McMullen and Dimov 2013; Shepherd et al. 2015). While specific decisions can be pivotal in setting a course of action, resulting actions and directions can also be reconsidered and altered. Hence, we favor a conception of entrepreneurial judgment as a series of decisions strung together over time (McMullen 2015). Here we adopt insights from the dynamic decision-making literature and control theory to describe the dynamic nature of entrepreneurial judgment and the continuous evaluation of those judgments.

Dynamic judgment is a continuous process by which judgments are made, evaluated, and remade

over intervals of time (see Figure 3). Both endogenous and exogenous factors combine to produce a new environment, moving the venture toward or away from the desired end. As these effects are observed and evaluated against expected progress, changes are made to redirect the venture more closely toward the desired outcome, or even to alter the desired or expected outcome (Wiltbank et al. 2006).

Feedback regarding the effects of action and the changing state of the environment on the outcomes of interest is critical to this process (Klein 1989). As new information is considered, new judgments are made. Witte (1972: 180) observes, “human beings cannot gather information without in some way simultaneously developing alternatives. They cannot avoid evaluating these alternatives immediately, and in doing this they are forced to a decision.” Research suggests there may be a general tendency or bias toward staying the course (e.g. Dhar 1997; Dhar and Nowlis 2004; Mann et al. 1997), but a single judgment is rarely fully deterministic (see, e.g., DeTienne 2010; Nelson and Winter 1982).

Insert Figure 3 about here

Certainly, the entrepreneur must also consider the costs of frequent course alteration and of the required feedback monitoring. First, each new action may involve an up-front cost, as well as sunk costs of an abandoned plan. Change also generally precludes the ability to establish production routines and relationships needed to reduce costs (Zollo and Winter 2002). Data monitoring and environmental scanning may also be costly (Beal 2000; Hambrick 1982). Entrepreneurs, then, must balance avoiding costly delays in adaptation and incurring excessive costs in unnecessary monitoring and change.

Effectuation theory can be viewed as a strategic and intentional employment of dynamic and continuous judgment in uncertain conditions. That is, by recognizing uncertainty, entrepreneurs can minimize their commitment to *ex ante* plans and avoid much of the costs of altering those plans as new information is obtained. Loss aversion biases are thus averted, and the entrepreneur is less likely to be attached to a bad idea. In short, effectuation attempts to maximize the effectiveness of dynamic judgment.

4.3 Uncertainty Transitions

Thus far, we have depicted dynamic and continuous judgment as a function of shifting environmental factors. As these shifts occur, the nature or type of uncertainty may transition to a new state. Transitions to lower-order uncertainty, which we portray as the expected pattern of the entrepreneurial judgment process, are only part of the narrative. Dynamic judgment, as described in the preceding section, implies that uncertainty after entrepreneurial judgment shifts from one state to another as environmental conditions change, as new information is learned, and as entrepreneurs make new judgments. That is, action, whether by the entrepreneur (endogenous), or by exogenous factors (e.g. other actors, environmental change), may alter the recognized set of options or set of outcomes such that a new uncertainty type is attained. Two types of transitional shifts may occur over time, one toward a lower-level uncertainty (i.e., toward risk) and another toward a higher-level uncertainty (i.e., toward absolute uncertainty). Here we review why and when these transitions may occur. The examples in this section are meant as illustrative, not universally descriptive. We focus on certain cases of transitions that we believe are generally typical, but acknowledge that other transitions are possible.

Transitions to lower-level uncertainty occur through judgment. While such judgments are made endogenously, exogenous feedback may also cause reconsideration and new judgment about sets of options or outcomes. For example, over time new information may make a set appear closed, i.e., that all options or outcomes have been considered. While in rare cases there may be a true exhaustion of options or outcomes, most likely this is an artificial sense of completeness. Such a sense may occur, for example, when the entrepreneur has spent considerable time looking for new alternatives to no avail, leading to a conclusion that there are none. Or, it may come from the observation of repeated outcomes such that the situation appears probabilistic. Here, the entrepreneur transitions from a higher state of perceived uncertainty to a lower one—from absolute uncertainty into spaces of creative or environmental uncertainty. Further judgments can, similarly, transition a case of environmental or creative uncertainty into one of ambiguity or risk. In each case, entrepreneurial activity is moving to close the open sets.

Notably, creative and environmental uncertainties are always present and cannot be fully resolved. Markets are open systems, and there is always a possibility of exogenous or endogenous change that actors cannot predict or control. However, long-term market stability can lead entrepreneurs to assume that such change is unlikely, prompting them to limit the sets of options and outcomes and adopt a risk/ambiguity perspective. Exogenous shocks and endogenous decision, however, can spur transitions back to higher levels of uncertainty. Investment banking, for example, enjoyed long-term success and stability, facilitating the employment of lenient standards and lending routines. With the unanticipated 2008 crisis in the real estate market, however, the investment banking industry was shaken, prompting it to reconsider its practices.

As the banking example illustrates, acting under (mistaken) assumptions of risk/ambiguity can be precarious. It encourages probabilistic analysis of markets, routinization, and other optimization practices, which may lead to organizational rigidity (Leonard-Barton 1992) and leave the actor vulnerable to unanticipated exogenous shocks from environmental change or innovation. Exogenous change from technology, competitors, regulation, and the like can push actors to reopen their sets of outcomes or options. Experience or observation may show that constraints previously placed on the set of options are false or no longer relevant. Exogenous change does not *cause* closed sets to open, but actors learn in response to their observations of exogenous events and choose to reopen those sets through new judgment. Thus, inexperienced entrepreneurs tend toward assumptions of risk or weak environmental uncertainty, resulting in overconfidence, whereas experienced entrepreneurs tend to be more realistic about the true uncertainties underlying their judgments (Dew et al. 2009a).

In summary, opening outcome and option sets changes the decision context from lower- to higher-level uncertainty, placing the entrepreneur back at the beginning of the entrepreneurial judgment process. As exogenous factors open up the set of outcomes, which in turn prompts an endogenous revisiting of the set of options, the process recurs. This recursive process brings to mind Schumpeter's (1942) account of the "perennial gale of creative destruction," as entrepreneurs and firms continue to act entrepreneurially through innovation in search of sustainable profitability (Wiggins and Ruefli 2005).

Insert Figure 4 about here

4.4 The Case of Netflix

Consider, as an example of this dynamic process, the origins and growth of movie-distribution company Netflix, as recounted by Keating (2012). This process is illustrated in Figure 4, a combination of Figures 2 and 3, with key states and events numbered as indicated below. The Netflix story begins with absolute uncertainty as Reed Hastings, CEO of Pure Atria, and Marc Randolph, corporate marketing manager, speculated about the future as the firm merged with rival Rational Software. It was the middle of the dot-com boom of the late 1990s, and Randolph was interested in starting a new internet company (1). Having experience with direct shipping from an online store, Randolph suggested direct shipping of VHS movie rentals as a means to cut down on inventory and overhead costs (2). This idea was quickly rejected because of high shipping and inventory costs of VHS cassettes (3, 4).

Randolph later learned of emerging DVD technology and, seeing that the technology potentially resolved the problems of VHS (5), the friends wondered if such discs could be safely mailed. Unable to secure a (then) rare DVD to field test the concept, they successfully mailed a music CD to themselves in a large greeting card envelope, coming to a state of perceived opportunity (6). With a solution in hand to accompany the growing momentum of online stores, along with a need for new employment, Randolph launched Netflix in April of 1998 with the help of \$2.5 million from Hastings (7). Its original model mimicked the traditional pay-as-you-go movie rental model, but boasted a DVD inventory that could outshine any brick-and-mortar store.

Despite some early success, the company struggled to achieve profitability. In 1999, the situation reverted to one of absolute uncertainty, starting the entrepreneurial process anew (8). Taking a causal approach, the company tried to entice new customers without changing the service, closing the outcome set (9). Randolph and Hastings (who took over leadership) added the personalized user profile and recommendation system, and considered a subscription model without late fees, moving again to a state of perceived opportunity (10). Having achieved economies of scale by this time for such a model to work, the

subscription service was launched in late September (11), an innovation that proved so successful that the pay-as-you-go service was soon discontinued.

With this success, however, came strong imitation from firms like DVD Rental Central.com and Blockbuster video, as well as competitive pressure from retail giant Walmart. Uncertainty surrounding the industry and Netflix's place quickly escalated as shares fell from \$14 to below \$6. In response to this heightened uncertainty, Hastings and company returned to a perception of absolute uncertainty (12). They again restarted the judgment process, opening up the set of options to consider new ways to keep subscribers away from the growing competition, opting for a causal process (13). The solution this time was to improve distribution time by building distribution facilities near metropolitan areas, allowing overnight delivery for a large percentage of their customer base (14). While costly, this was seen as necessary to stave off the well-funded competition (15). The move was successful, as subscribers broke the 1 million mark and the firm again became profitable.

In the following years the firm was again confronted again with heightened uncertainty as online video streaming technology emerged as a popular alternative (16). Netflix responded with an effectual approach in developing its own online streaming technology, giving subscribers free streaming of a few titles as a hedge against the changing environment (17, 18). It was a costly endeavor, but Hastings judged the long-term future to be in instant access (19). This model proved to be only an intermediate step, however, as Netflix would soon look to curtail the encroachment of growing streaming services from Hulu, Amazon, and Apple by integrating the streaming service into its unlimited content subscription model (20, 21, 22, 23). The dynamic judgment process would continue for Netflix as they considered other strategic options such as producing its own content, but the narrative here is sufficient to our illustration of recursive entrepreneurship in response to ever-changing conditions of uncertainty (cf. Wiggins and Ruefli 2005).

5. IMPLICATIONS AND CONCLUSION

Uncertainty has long been recognized as a critical factor in entrepreneurship research (e.g. Knight 1921; Mises 1951). Yet this research has been hindered by the challenge of describing the source, nature,

and effects of uncertainty. We offer three key contributions to this literature. First, we offer a novel approach to understanding uncertainty, employing set theory and probability theory to piece together *how* or *why* a decision context is uncertain, i.e., why probabilities do or do not exist. Second, we use the theory of potential surprise to explore the nature of entrepreneurial decision making within the different contexts of uncertainty. Finally, we apply our understanding of uncertainty and decision making toward extending dynamic decision theories in terms of when and why new judgments are made over time, responding to recent calls for research on entrepreneurial dynamics (McMullen and Dimov 2013; Shepherd et al. 2015). The judgment process, as we conceptualize it, represents not a rational choice process, as it is typically framed, but rather a “dance” with uncertainty. Entrepreneurs move with, or in response to, their perceptions about uncertainty, pursuing new ways to fit to the changing uncertainties or to endogenously shape the transition of those uncertainties such that it conforms more strongly to their own strengths and resources (cf. Jauch and Kraft 1986; Pacheco-de-Almeida and Zemsky 2012).

5.1. Contribution to Decision Theory

Uncertainty is, by nature, difficult to unpack. Indeed, the literature has not moved far beyond Knight’s seminal typology, distinguishing risk, where probabilities exist, and uncertainty, where they do not. A challenge in developing a richer account of entrepreneurial judgment under uncertainty, and the dynamic nature of entrepreneurial decisions, is that empirical researchers have tended to oversimplify the context in which judgment occurs. Careful, grounded empirical work, both inductive and deductive, is critical for motivating new theory and keeping theories based in reality (Suddaby 2014). But measurement poses a special challenge for analyzing complex phenomena such as uncertainty.

Our approach offers a new way to think about uncertainty. Because a decision is comprised of two sets, options and outcomes (Shackle 1949), we can extend Knight’s typology by applying set theory (Zermelo 1908; Cohen 1966) to characterize these sets and describe how and why decisions lack the requirements for probabilities and are, therefore, uncertain. The result is new insights into how decisions are made and why they are almost never fully deterministic.

This exposition on decision making suggests that prominent decision-making frameworks, built

on probability theory and assumptions of risk (e.g. Savage 1954; Kahneman and Tversky 1979), cannot properly deal with the uncertain contexts common to entrepreneurship. Instead, we have turned to Shackle's (1949, 1961) theory of potential surprise, which employs subjective perceptions of *possibility* as an alternative to rational choice theory's probability estimation. We find this a workable foundation for entrepreneurship theory. We thus contribute to the judgment and decision-making literatures, both within and outside of the entrepreneurship domain, in (re)introducing Shackle's decision framework as a more appropriate alternative in such uncertain contexts.

These insights let us construct a more refined and robust framework for analyzing dynamic judgment. Researchers have recently observed the need for such a dynamic framework and have begun to lay groundwork (e.g. Austin et al. 2012, Dimov 2011, McMullen 2015, McMullen and Dimov 2013, Shepherd et al. 2015; Smith 2014). We extend this research, detailing distinct dynamic decision processes in accordance with effectuation theory (Sarasvathy 2001). That is, entrepreneurial judgments may take a causal approach, making and implementing plans according to the entrepreneur's expectations of future outcomes. Alternatively, they may employ an effectuation process, responding to a perceived uncertain context by minimizing the commitment to *ex ante* plans, pursuing new information, and revising the plan of action accordingly. Over time, the perceived nature of uncertainty may shift as unexpected events occur (pushing the entrepreneur to reconsider the set of outcomes), as new technologies become available (opening up new option possibilities), as prolonged industry stability prompts the entrepreneur to consider the set of outcomes closed, and so forth. As new uncertainties are perceived, new judgments are also made, even toggling between causal and effectual approaches as necessary.

5.2. Uncertainty and Effectuation

We also contribute to effectuation theory. First, we describe the uncertain contexts in which effectuation processes are relevant, distinguishing them from traditional risk and ambiguity contexts that are often the focus of uncertainty studies. Second, we describe how causation and effectuation processes can be understood *within* the decision-making process itself—i.e., taking a causal or effectual path from abso-

lute uncertainty toward judgment—and not only as a form of dynamic decision making. Third, we illustrate how causal and effectual processes are not exclusive paths, but may be complementary, used alternatively in response to transitioning uncertainty. Finally, we provide a new framework for understanding when and why causal or effectual judgment processes may be taken, and by whom.

Our framework suggests that how an entrepreneur perceives uncertainty will facilitate one decision-making approach or another: those who perceive their outcome set as finite and determinable (i.e. closed) will tend toward a causal approach, whereas those who perceive that set to be open will tend toward effectual processes. This and future research can thus facilitate a more nuanced explanation of why some entrepreneurs perceive uncertainty in a particular way. Inexperience, for example, may lead to a poor understanding of uncertainty—in large part because the inexperienced entrepreneur’s cognitive map of reality is comparatively underdeveloped—and therefore tends to produce overconfidence and causal planning (e.g. Hayward et al. 2006, Dew et al. 2009a).

While this paper is not specifically intended as a defense or extension of effectuation theory, it addresses recent criticisms of effectuation such as the validity of certain assumptions, its perceived lack of a causal explanation (i.e. when and why do entrepreneurs choose causation or effectuation?), and a lack of a theoretical connection to prior research (Arend et al. 2015).

5.3. Implications and Future Directions

Because uncertainty plays a fundamental role in many theoretical contexts and in various research domains, our approach can facilitate new insights in many areas. First, our approach opens a new road for the study of uncertainty itself. For example, further theoretical and empirical disentangling of *perceived* and *true* uncertainties is needed (Lueg and Borisov 2014). Also, exogenous and endogenous sources of change and the types of uncertainty they produce should be more thoroughly explored.

As it becomes increasingly clear that rational choice theory cannot satisfactorily describe decisions in many real-world contexts, we call for a theoretical shift toward a different framework, one that eschews probability theory and more closely resembles actual decision making under uncertainty. While

we believe the theory of potential surprise is a strong point of entry here, the theory remains underdeveloped and more work is needed. There are other promising frameworks that have, so far, received little attention (e.g. the fuzzy set theory of Bellman and Zadeh 1970). Because managers and entrepreneurs generally reject simplistic probability-based decision models (Harrison 1977, Mintzberg et al. 1976, ogilvie 1998), qualitative and other empirical research may move us toward a more descriptive view of the actual decision processes by which entrepreneurs make judgments under uncertainty, refining the theory of potential surprise or whatever other framework emerges. The development of such theories may begin to address additional questions about processes of entrepreneurial judgment.

Second, entrepreneurship research can benefit from a better foundational understanding of uncertainty and dynamic judgment processes. Future research should include empirical investigation of the performance implications of entrepreneurs' perceptions of different types of uncertainty. What are the effects of uncertainty on the process of judgment itself? Does the determination of a type of uncertainty (i.e. the way the question is asked) constitute a judgment itself, or is it more of an instinctual or reactive process? Future work is also needed to more fully unpack when, why, and how decision makers transition from one state of uncertainty to another and what factors might influence such transitions.

Our research may also offer insights into the nature of entrepreneurship and opportunities. For example, a "discovery" of opportunities (Shane 2012) may be understood where the entrepreneur perceives risk or ambiguity, whereas the "creation" of opportunities (Alvarez et al. 2013) might result from a perceived creative uncertainty context. In a perceived environmental or absolute uncertainty state, we cannot know if any given option is an opportunity *ex ante*, and so opportunities can only be said to be "imagined" by the entrepreneur (Klein 2008). Future research might explore the relationship between the type of uncertainty perceived, the supposed nature of perceived opportunities and the subsequent behavior of entrepreneurs, and the outcomes of that entrepreneurship.

Finally, there are various insights that other fields can glean, both within and outside the management domain. Strategy and human resources research are concerned with the role of uncertainty in managerial decision making. Moreover, we can employ this framework in other organizational domains such as

consumer behavior and finance. We may also observe that this framework challenges, at a fundamental level, some of the assumptions on which neoclassical economics is built, as derived from the expected utility framework. If we are to move toward recognizing Knightian uncertainties as described here, such basic frameworks, built only on conceptions of risk, are ill-suited to describe actual behavior, and are therefore problematic for our theory and empirics.

We give the final word to artist Georg Baselitz (2010): “I always work out of uncertainty, but when a painting’s finished it becomes a fixed idea, apparently a final statement. In time, though, uncertainty returns . . . your thought process goes on.”

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Figure 1 Uncertainty Typology

		Set of Outcomes ¹	
		Closed	Open
Set of Options ²	Closed	Risk/Ambiguity <i>e.g. insurance, gambling</i>	Environmental Uncertainty <i>e.g. make or buy decision</i>
	Open	Creative Uncertainty <i>e.g. find a solution to a problem</i>	Absolute Uncertainty <i>e.g. commercialization of radically new technologies</i>

¹ Includes all foreseen outcomes, imagined or given, that are considered possible as a result of some considered course of action.

² Includes all possible courses of action, imagined or given, that are considered potentially viable in generating some preferred outcome.

Figure 2 Model of the Entrepreneurial Judgment Process Originating in Absolute Uncertainty

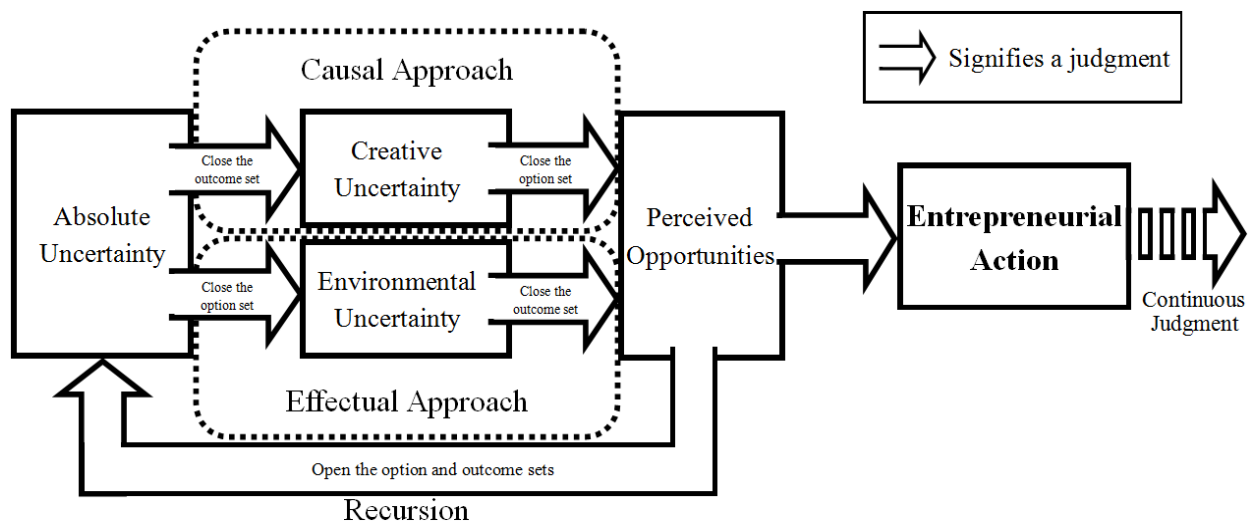


Figure 3 The Continuous Judgment Process

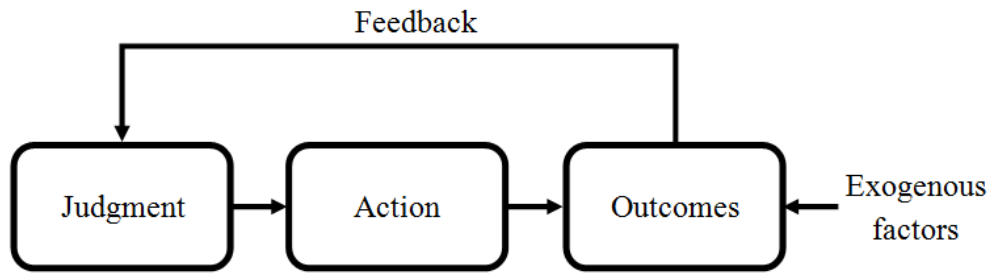


Figure 4 Netflix Example of the Continuous Judgment Process

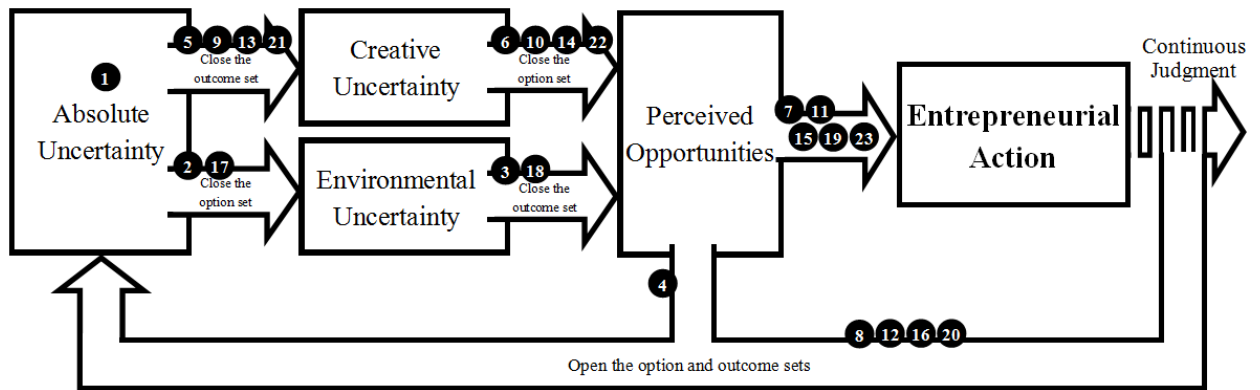


Table 1 Comparison of Uncertainty Typologies

Scholar	Types of Uncertainty			
	Risk	Uncertainty	Indeterminacy	Contingency
Knight (1921)	Risk	Uncertainty		
Savage (1954)	Risk	Ignorance		
Shubik (1954)	Risk	Ambiguity		
Ellsberg (1961)	Risk	Incompleteness		
Thompson (1967)				
Milliken (1987)				State Uncertainty Effect Uncertainty Response Uncertainty
Spender (1989)		Incompleteness		Indeterminacy Incommensurability (Irrelevance)
Dosi & Egidi (1991)		Substantive Uncertainty Procedural Uncertainty		
Dequech (2011)	----- Weak Uncertainty ----- Risk	Ambiguity	----- Procedural/Substantive Uncertainty ----- ----- Fundamental Uncertainty -----	----- Strong Uncertainty -----
	Risk	Ambiguity	Creative Uncertainty	Environmental Uncertainty
				Absolute Uncertainty