

Strategic Management of Uncertainty: An Integrative Thread for Our Field

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ABSTRACT

Scholars have long sought to understand the role of uncertainty within strategic management theory and practice. These efforts have unfortunately become fragmented across subfields, leading to isolated debates and a divided research community. To address this problem, we propose viewing uncertainty as a unifying thread that connects diverse topics within the broad domain of strategic management. Our categorization of uncertainty helps foster collaboration among strategy scholars and offers a perspective to help managers and students understand when to apply specific tools promoted in strategy and entrepreneurship courses. Our aim is to facilitate a more inclusive dialogue by positioning uncertainty as a central, integrative theme in strategy research.

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1. Introduction

Business uncertainty is pervasive, creating both challenges and opportunities for strategic management. Scholars and consultants have long sought to understand uncertainty's role in strategic management theories and practices.¹ In their renowned call to action for strategy research, Rumelt, Schendel, and Teece identified uncertainty as one of the five “conceptual monkey wrenches” (1994, p.26) that trigger fundamental questions in strategy.

Ironically, early works in strategy largely overlooked “uncertainty.” For example, uncertainty plays no explicit role in Porter's (1980, 1985) classic concepts of “Five Forces” and “Competitive Advantage.” The strategy field has evolved in diverse directions, from a static view to more dynamic perspectives (Helfat and Eisenhardt, 2004; Teece, 2007; Ghemawat, 2016). Today, many strategic management studies incorporate uncertainty.

Contemporary strategy scholars emphasize uncertainty as a key element that makes decisions strategic and strategy valuable (Van den Steen, 2017, 2018; Leiblein et al., 2018), and they find that taking a strategy class helps students become “more aware of the uncertainty pervading strategic decisions” (Heshmati and Csaszar, 2024, p.453). Scholarly discussions on how management theories can better tackle uncertainty have received renewed attention (Alvarez et al., 2018; Alvarez and Porac, 2020), including debates in this journal (Bettis and Blettner, 2020; Furr and Eggers, 2021; Ehrig and Foss, 2022; Camuffo et al., 2023; Ao et al., 2026). Uncertainty is also

¹ This large body of literature includes, for example, Levinthal and March, 1981; Rumelt, 1987; Wernerfelt and Karnani, 1987; Mitchell, 1989; Ghemawat, 1991; Collis, 1992; Miller, 1992; Sanchez, 1993; Bettis and Hitt, 1995; Brown and Eisenhardt, 1997; McGrath and MacMillan, 2000; Anderson and Tushman, 2001; Carpenter and Fredrickson, 2001; Schoemaker, 2002; Foss and Knudsen, 2003; Grant, 2003; Alvarez and Barney, 2005, 2007; Folta, 2005, 2007; Wiltbank et al., 2006; Li et al., 2007; Kor et al., 2008; Sull, 2009; Smit and Trigeorgis, 2017; Van den Steen, 2017; Rindova and Courtney, 2020; Teece, 2020; Kapoor and Klueter, 2021; Kuipers et al., 2021; Gigerenzer et al., 2022; Mankins and Gottfredson, 2022; Reeves and Job, 2023; Arend, 2024b; Toh and Pyun, 2024; Almeida Costa and Gimeno, 2026; Gambardella and Messinese, 2025; Sakhartov et al., 2026; Zellweger and Djokovic, 2026.

an important construct for academics and managers to assess whether and when research findings from one setting apply in another (Levinthal and Rosenkopf, 2026).

Despite increased scholarly attention, the 2025 Global Strategy Survey of Chief Strategy Officers and academics highlights that uncertainty remains an “untamed issue in strategy” (Chaudhuri et al., 2026). Consulting studies show low adoption of tools like scenario planning to manage this uncertainty, even though adopters report high satisfaction (Bain, 2023).² McKinsey research indicates that most firms overlook uncertainty in their strategies, either ignoring it or treating it as an afterthought (Bradley et al., 2018). Although executives recognize uncertainties and know their strategies must fit environmental conditions, many firms still choose classic (static) approaches, even when their environment is unpredictable (Reeves et al., 2015). This is a lost opportunity, because strategic management tools can help managers and entrepreneurs manage the downsides and unlock the upsides of uncertainty.

The accumulated research on strategic management under uncertainty lacks integration, partly because *uncertainty* spans multiple research areas with independent debates. This issue is exacerbated by the “balkanization” of the strategy field, which has become increasingly disconnected and entrenched in its specialties (Durand et al., 2017; Schoemaker, 2026).

In this article, we maintain that the strategic management field now has an opportunity to define itself more clearly by bringing diverse scholars together around a unifying topic: the management of uncertainty. Similarly, on the teaching side, we submit that the field has an opportunity to create a more integrated set of classroom materials to educate managers.

² In a study comparing CFO surveys conducted in 2001 and 2022 on the use of decision rules in capital allocations, Graham (2022, pp.1984-1988) finds that while the use of NPV still dominates in capital allocations, the use of scenarios, simulations, and real options in corporate investment decisions has increased.

Thus, three decades after Rumelt, Schendel, and Teece (1994), it remains legitimate to ask: How well has the field addressed problems related to strategic management under uncertainty? We contend that over the past three decades, the strategic management field has developed methods, techniques, and perspectives relating to uncertainty, but these approaches have not been integrated under a common umbrella. Many scholars exploring new approaches (such as real options, lean-startup methods, and industry “shaping”) have worked in silos, largely unaware of how their work fits into the broader landscape in dealing with strategic uncertainty.

Our aim is to sketch out some key elements of this landscape. We take a broad perspective, focusing on the opportunity to foster greater cohesion in the field and address its “balkanization.” Moreover, we note that in training managers, the field has developed many relevant managerial tools to address uncertainty, but it has never integrated these tools into a larger toolbox with clearly defined compartments and interconnections.³

Below, we develop this perspective through four lines of inquiry: (1) we discuss the role of uncertainty in core theories and research topics of the strategy field, (2) we propose uncertainty as a thread that cuts across different areas of strategic management, thereby providing a vehicle to unite diverse scholars, (3) we treat *level of uncertainty* not only as a condition that firms encounter but also as one they partly choose and change (via shaping, via investments in learning, and via the selection of arenas in which to compete), and (4) we provide an intellectual “toolkit” for managers and scholars to interlink conversations that address the topic of uncertainty, bring it into the classroom, and facilitate discussion. Thus, we seek to contribute to a broader conversation in the field by framing strategy through the lens of strategic management under uncertainty.

³ Exceptions are Courtney (2001) and Courtney and colleagues (1997), whose framework we elaborate on.

2. Definition of *Uncertainty* and a Structuring Lens

2.1 Prior Categorization Efforts

Prior research has proposed multiple categorizations and definitions of uncertainty (Knight, 1921; Milliken, 1987; Miller, 1992; Rosenberg, 2009; Packard et al., 2017). In this review, we focus on uncertainties related to external factors, including demand, technological, political, regulatory, ecosystem, and competitive uncertainties. This focus includes, for instance, a firm's uncertainty about the success of new products because customer preferences are uncertain. By *uncertainty*, we refer to unpredictability as a lack of ability to predict future events. It is characterized by a future that diverges from the past in unforeseeable ways, with information about the future incomplete, unknown, or unavailable (e.g., Davis et al., 2009).⁴

Many reviews and overview articles on uncertainty have been published in strategic management (Sund et al., 2022; Arend, 2024a) and related fields (Liesch et al., 2011; Bloom, 2014; Packard et al., 2017; Magnani and Zuchella, 2018; Arend, 2024b; Bruno and Henisz, 2026; Dorobat et al., 2026). Yet they primarily define and measure uncertainty, offering limited integrative insights on firm behavior and the outcomes of strategic decisions under uncertainty. (See Appendix A for a summary of these overviews.) Other theoretical (e.g., on real-option theory: Li, 2007; Li et al., 2007; Driouchi and Bennett, 2012; Trigeorgis and Reuer, 2017; Chi et al., 2019; Chintakananda et al., 2025), phenomenological (e.g., on investments: Carruth et al., 2000), or meta-analytical reviews (Cadeaux and Ng, 2012; Delios et al., 2025) provide less detail about the scope of potential strategic decisions.

⁴ Uncertainty may also arise from internal factors, such as a firm's ability to adopt a new technology successfully. Such organizational uncertainties are outside our primary scope. Our inclusion criterion is whether uncertainty bears on a firm's strategic choices, wherever it originates. This criterion admits, for example, the behavioral uncertainty of transaction cost economics and the causal ambiguity of the resource-based view, as both shape strategic decisions about governance and imitation. However, most uncertainty within organizations—for example, in organizational design or change management—remains beyond the scope of this review.

Despite these prior contributions, we cast a wide net in our review, aiming to connect a diverse range of contributions. We adopt, as an integrating device, the categorization outlined by Courtney, Kirkland, and Viguerie (1997), which proposed that uncertainty can be seen along a continuum with four levels: Level 1, which posits “a clear-enough future that is predictable enough”; Level 2, in which alternative states are known (with or without probabilities); Level 3, in which there is a range of potential futures (without discrete scenarios); and Level 4, a state of ambiguity that does not allow a range of possible future outcomes to even be defined.⁵ We utilize these levels of uncertainty to categorize existing research contributions by placing them into these “boxes” and structuring our discussion accordingly. We classify each reviewed study by the level of uncertainty it examines, then we cluster studies into themes within each level (see Table 2).

Table 1: Four Levels of Uncertainty (adapted from Courtney et al., 1997; Courtney, 2001)

Level 1: Clear-enough future	Level 2: Alternate futures	Level 3: A range of futures	Level 4: True ambiguity
Can define a single view of the future, even if not all drivers are entirely predictable.	Can define a limited set of possible future outcomes (scenarios), one of which will occur.	Can define a range of possible future outcomes, but not discrete scenarios.	Cannot define even a range of futures.

While the transition between these categories is often seamless, the most consequential boundary between Levels 3 and 4 can nevertheless be sharpened by asking whether opportunities are discovered or created, a distinction proposed by Alvarez and Barney (2007) that we elaborate in Section 3. Nor are the levels purely exogenous: as we develop in Sections 3 and 5, firms can deliberately move between them and even select the level at which they engage. The levels also

⁵ Courtney and colleagues (1997) use the term *ambiguity* for Level 4 uncertainty; it should not be confused with causal ambiguity, a “decision maker’s inability to discern the causal structure that leads to his firm’s success or failure” (Mosakowski, 1997, p.414).

have an epistemic dimension. They describe the decision situation as it presents itself to a particular actor, not as an objective property of the environment alone: assessing which level a firm faces is an interpretive act, shaped by attention, experience, and framing (Milliken, 1987; Kaplan, 2008). Two firms in the same environment may therefore diagnose different levels and act accordingly, and a firm may revise its diagnosis as its understanding develops.

Despite this perceptual subjectivity, using four levels of uncertainty simplifies the mapping of extant studies and challenges the binary view of certainty or uncertainty. Our “four box” approach is simple yet nuanced enough to unify the dispersed research on strategic management under uncertainty. It also has classroom appeal for illustrating how extant research is relevant to addressing managerial challenges.

2.2 Our Approach

This article is an integrative review, not a systematic one. Systematic review protocols presuppose that the phenomenon of interest can be captured by a stable set of search terms. Uncertainty cannot: as we document below, the construct travels through the strategy literature under many partially overlapping labels, and the literatures that use these labels cite each other only sparsely.⁶ We selected research studies related to uncertainty and have organized them to reflect our view of problems and opportunities in the strategic management field.

Before we get into the details of our arguments, it may help to preview some of our central observations and points regarding the four “boxes” of uncertainty and how they connect. Much of

⁶ A keyword-driven search would inherit the vocabulary of one silo and systematically miss the others; the fragmentation this paper addresses is precisely what defeats the protocol. We rely on expert curation of a corpus that we have assembled over more than a decade of research and teaching on strategic decision-making under uncertainty, extended through backward and forward citation tracking from seminal works in each of the literatures mapped in Section 3, and spanning leading journals in strategic management, organization theory and entrepreneurship, together with influential practitioner publications. To check the corpus for blind spots, we circulated the tables to colleagues, adding works we had missed. We do not claim completeness, and the relative cell frequencies in our tables should be read as indicative of emphasis in the literatures we cover. Our aim is comprehensiveness of perspectives, not exhaustiveness of studies.

the early research in the field was conducted in the L1 box, building on the dominant theories in strategy (see Table 2). Research explicitly addressing uncertainty is primarily found in the L2 and L3 boxes; less is found in the L4 box. Part of this pattern may be an artifact of our corpus, since Level 3 is where uncertainty is most likely to be labeled as such, whereas Level 2 and Level 4 work often travels under other names. Research also concentrates where uncertainty is most tractable: Level 3 is the only level that maps onto continuous, measurable variables and thus onto large-sample empirical designs; Level 4, by definition, tends to resist measurement. Moreover, strategy inherited its formal apparatus from economics and finance, which model uncertainty as distributions over ranges and set Knightian unknowability aside as intractable.

Following Knight's (1921) distinction between risk and uncertainty, the studies in the L2 box largely cover "risk" (i.e., probabilities can be calculated), with fewer studies examining discrete uncertain future states without probabilities.⁷ "Knightian uncertainty" is prevalent in studies categorized in the L3 box (known unknowns) and the L4 box (unknown unknowns). Even so, we do not embrace Knight's view: we suggest that the limitation of Knight's century-old distinction is not that it is wrong but that it is insufficiently granular for strategic management. At a minimum, we consider it important to distinguish between Levels 3 and 4; the situations in these categories call for different tools and different logics of action. Indeed, others have proposed graded frameworks that preserve Knight's insight that not all uncertainty is risk while recognizing distinctions that are relevant to strategic choice.⁸ In short, we maintain that Knight's dichotomization is too simple for the contemporary field of strategic management, so we structure

⁷ Comparing the field of strategic management with competition economics and urging management scholars to inform competition policy, Teece (2023, p.5) points out that competition economics assumes a business environment that is characterized by quantifiable risk, whereas strategic management is about uncertainty.

⁸ For example, Packard and colleagues (2017) distinguish two subcategories of Knightian uncertainty that correspond, roughly, to Levels 3 and 4 in Courtney and colleagues' (1997) continuum.

our insights on how uncertainty affects behaviors, decisions, and outcomes through the lens of the four boxes.

Table 2 organizes research topics into the four levels of uncertainty; similarly, Table 3 organizes management-oriented strategy tools. Thus, Table 2 guides researchers, while Table 3 is designed for classroom use. In assigning entries to levels, we follow two rules: for Table 2, the research streams reflect the levels of uncertainty examined by the reviewed studies (see the Table 2 note), while for Table 3, the tools are placed at their most common application level and where, in our reading, their core assumptions fit best. We call this a tool's home level.

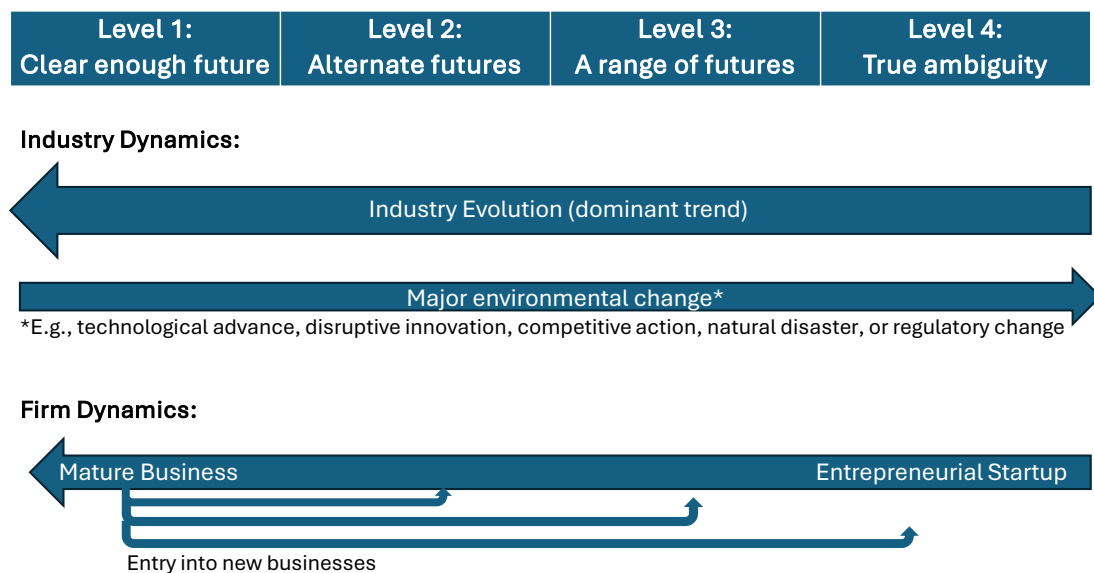
Nevertheless, many entries span levels. Real-options reasoning, for example, is most at home at Level 3 but also informs staged commitments at Level 2; scenario planning, it has been argued, spans Levels 2 through 4 (Courtney, 2003); shaping strategies, while most prominent under deep uncertainty, apply across all levels (Courtney et al., 1997); and dynamic capabilities are positioned by Teece and colleagues in deep uncertainty, even though much empirical work applies them under Level 2 and Level 3 conditions. Thus, placement indicates emphasis rather than exclusivity, and the tables should be seen as maps to refine rather than as a settled taxonomy.

After categorizing the extant research on uncertainty (Section 3) and characterizing the set of managerial tools (Section 4), we address (in Section 5) various dynamics that further motivate the need to integrate contributions and debates. For instance, uncertainty tends to resolve over time from Level 4 to lower levels; therefore, firms tend to move leftward in Table 1. Firms may reduce uncertainty through their own experimentation efforts (Packard et al. 2017, p.850), or the “uncertainty fog” may dissipate due to exogenous forces. Leftward shifts also occur in an industry as firms learn and share knowledge. These uncertainty transitions require adaptability in the decision-making process and in the approaches chosen to tackle uncertainty.

Less commonly, rightward shifts occur when a major environmental change (e.g., technological advance, competitive action, natural disaster, or regulatory change) increases uncertainty, requiring that established firms adapt. Firms also move rightward when they enter new businesses that are more uncertain than their existing business(es). These dynamics stem from industry-level or firm-level phenomena, as sketched in Figure 1. Some firms may also intentionally create uncertainty for other firms, for example, by making unpredictable competitive moves or by benefiting from market disequilibrium through disruption. Finally, different uncertainties may interact, complicating strategic decision-making.

As we note in Sections 5 and 6, many of these transitions across the uncertainty boxes remain relatively unexplored and are at the cutting edge of strategic management research.

Figure 1. Industry and Firm Dynamics Across Uncertainty Levels



2.3. Benefits of Integration

Before mapping the literature onto the four-level framework, we should be explicit about what our integration adds to the strategy field. Showing that researchers consider uncertainty in many subfields establishes that it is pervasive, not that it is unifying. A skeptic could object that the uncertainty of real-options theory, the unpredictability of competitive dynamics, and the unknowability of effectuation research are different constructs sharing a label. However, we submit that integration provides benefits that no single literature can generate from within its own boundaries, for several reasons:

First, integration clarifies long-standing debates by revealing conditions that operate differently across the four boxes. Consider, for example, commitment versus flexibility. One tradition holds that strategy is commitment: advantage comes from irreversible investments (Ghemawat, 1991). Another holds that irreversibility destroys the option value of waiting, so firms should stage investments and let uncertainty resolve (Dixit and Pindyck, 1994; McGrath, 1997). Through the four-level lens, these are not rival answers to one question. At Level 1, commitment is straightforward optimization. At Level 2, an irreversible move can deter rivals or tip an industry standard in the firm's favor; commitment serves as a game-theoretic device for preemption. At Level 3, where waiting is informative, flexibility promotes learning—options logic dominates here (Folta, 1998; Adner and Levinthal, 2004). At Level 4, both logics fail; commitments are made to create the future (Sarasvathy, 2001). A thirty-year debate dissolves into a contingency: the optimal strategic move depends on the level of uncertainty.⁹

Second, integration lets insights travel and accumulate across topic areas. Once literatures are indexed to levels, tools can transfer across settings at the same level: war-gaming from

⁹ The same diagnosis applies to the desirability of acting as a first-mover (versus waiting) and pursuing planned (versus emergent) strategy—disputes persisted because disputants implicitly held the level of uncertainty at different values.

competitive dynamics to regulatory scenarios; affordable loss from entrepreneurship to corporate venturing. The field's fragmentation is evident in parallel discoveries: probing (Brown and Eisenhardt, 1997), affordable loss (Sarasvathy, 2001), and small option bets (McGrath, 1999) are near-relatives developed largely in isolation. A common gradation provides what cumulative science requires; the current babel of terms (risk, ambiguity, turbulence, dynamism) impedes comparability of constructs across studies.

Third, integration turns the map into an agenda. White space is visible only on a map. Arranged in a common grid (Tables 2–3), the field's imbalances become inspectable: empirical work concentrated at Level 3, with thin coverage of Levels 2 and 4, tools without theories and theories without tools. The gaps identified in Section 6 highlight these research directions.

Fourth, integration illuminates the dynamics of uncertainty and makes the subject teachable. Questions about movement (i.e., how uncertainty resolves, escalates, or is deliberately reshaped; how multiple uncertainties interact) cannot be formulated within a single silo, as each treats its own level as a fixed-scope condition. Only a common scale makes “The uncertainty moved from Level 3 to Level 2” a meaningful sentence. The transitions examined in Section 5 stem from this integrated view. The same diagnostic layer answers practice's and the classroom's opening question, which no single tool can answer: “Which uncertainty do we face, and what toolkit does it require?” Moreover, as uncertainty shifts over time, the optimal policy must be reevaluated as the uncertainty landscape shifts—turning static trade-offs into dynamic policies.

2.4 An Illustrative Example: Shifting Uncertainties Faced by Uber

Uber's history provides an exemplar vignette to illustrate our framework. Founded in 2009, Uber faced at least four major uncertainties simultaneously, each at a different level, and each the home turf of a different strategy literature. *Demand uncertainty* (Would consumers summon

strangers' cars from an app?) began in the Level 3 range. *Competitive uncertainty* (How would Lyft, Didi, and local rivals respond?) was a Level 2 problem of discrete rival moves. *Regulatory uncertainty* (Was the service legal, and were drivers employees?) hovered between Levels 2 and 4 depending on the jurisdiction. And *technological uncertainty* (When, if ever, would autonomous vehicles arrive?) was Level 4—unbounded—though, as noted below, not everyone treated it that way. No single literature prescribes how to manage this configuration; each explains one piece.

These four types of uncertainty played out differently over time:

- The demand uncertainty was resolved the way the learning literature prescribes: by probing. City-by-city launches functioned as low-cost experiments, and within a few years the range of adoption outcomes had narrowed to near-certainty—a textbook learning-driven transition from Level 3 to Level 1, after which Uber's pricing and expansion decisions became conventional optimization problems.
- The competitive uncertainty played out as the competitive-dynamics literature would predict—price wars, subsidy battles, action and response—until 2016, when Uber ended its ruinous contest with Didi in China by selling its Chinese operations in exchange for a substantial equity stake in its rival. That move can be viewed as an options instrument applied to a competitive-dynamics problem. Uber converted an unwinnable Level 2 rivalry into a claim on whichever future materialized. The maneuver is illegible from inside either literature alone; on the integrated map, it is simply a tool from one level's toolkit imported to solve another literature's problem.
- The regulatory uncertainty is where Uber became the canonical shaper—what legal scholars call a regulatory entrepreneur (Pollman and Barry, 2017). Uber did not wait for the law to resolve; it launched ahead of it, mobilized riders as a political constituency, and, when California's AB5 reclassified drivers in 2020, spent (with its allies) a reported \$200 million on Proposition 22 to write its preferred rules into law. Two framework insights follow. First, shaping is a transition strategy: Uber was moving regulatory uncertainty leftward, from an unbounded question to a resolved one, on favorable terms. Second, the shaping was double-edged—by operating ahead of the law, Uber deliberately created uncertainty for taxi incumbents and regulators. Firms are producers of uncertainty, not only consumers of it. And shaping does not always win: the AB5 legislation and London's license revocations were shock-driven transitions imposed on Uber, rightward moves it then had to manage.

- The technological uncertainty exposes the cost of misdiagnosis. Autonomous driving was a Level 4 uncertainty—neither the timeline nor the eventual winner was boundable—yet Uber’s leadership treated it as Level 3, an “existential” race with a forecastable finish line, and committed billions to an in-house program. When the timeline failed to narrow, Uber reassessed its diagnosis and, in 2020, restructured its bet accordingly: it sold its Advanced Technologies Group to Aurora Innovation while investing in and retaining a substantial minority stake, thereby shedding the burn rate of a committed bet while keeping an option on the technology.

These uncertainties interacted—a configurational point no single-source study can capture.

The autonomous-vehicle bet was, in part, a hedge against the driver-classification uncertainty: a driverless fleet dissolves the employment question. And when COVID-19 delivered a shock that collapsed ride demand overnight, the delivery business absorbed it—a portfolio of initiatives spanning uncertainties, cushioning a shock to one with growth in another.

Uber’s strategic conduct (i.e., probing demand, war-gaming rivals, shaping regulators, optioning technology, and rebalancing the portfolio as levels moved) cannot be reconstructed by a single literature, as each explains one episode and treats the others as background. Our framework integrates these episodes into a single narrative, reflecting a firm running different logics simultaneously for uncertainties at different levels, switching logics as those levels moved, and succeeding based on the accuracy of its diagnoses. That is what our integrated perspective offers.

3. Strategy Research Contributions to Managing Level 1–4 Uncertainties

From an integrated perspective, Table 2 organizes a diverse set of strategic management studies into topics across the four levels of uncertainty.

Table 2: Strategy Research Topics That Address Different Levels of Uncertainty

Level 1: Clear-enough future	Level 2: Alternate futures	Level 3: A range of futures	Level 4: True ambiguity
- Strategic planning in stable environments (Ansoff, 1979) - Threats in the industry environment (Porter, 1980; 1985) - Strategy as positioning (Porter, 1985) - Sustained competitive advantage (Barney, 1995) - Zero-order (ordinary) capabilities (Winter, 2003)	- Discrete scenarios (Schoemaker 1993, 1995; Courtney, 2003; Phadnis et al., 2015; Belenzon et al., 2019; Bodrožić and Adler, 2022) - Decision trees (Trigeorgis, 1996; Smit and Trigeorgis, 2006a, 2007, 2017; Chevalier-Roignant and Trigeorgis, 2011; Trigeorgis et al., 2022; Smit and Moraitis, 2026) - Competitive dynamics (Dixit and Nalebuff, 1991; Chen and MacMillan, 1992; Ferrier, 2001; Guo et al. 2017; Nadkarni et al., 2019) - Competing technologies, technology substitution and hedging (Hatfield et al., 2001; Miller, 2002; Miller and Arikan, 2004; Lavie, 2006; Smit and Trigeorgis, 2006a; Eggers, 2012, 2016; Fisch and Ross, 2014; Moeen et al., 2020; Gans et al., 2021; Gao and McDonald, 2022; Chen et al., 2023; Furr and Snow, 2024)	- Wait-and-see (Wernerfelt and Karnani, 1987; Campa, 1993, 1994; Folta et al., 2006; Wu and Knott, 2006; Fisch, 2008; Belderbos and Zou, 2009; Li and Mahoney, 2011; Li and Chi, 2013; Damaraju et al., 2015; Claussen et al., 2018; Ross et al., 2018, 2023) - Experimentation (McGrath and MacMillan, 1995, 1999, 2000, 2009; Brown and Eisenhardt, 1997; Murray and Tripsas, 2004; Blank, 2013; Andries et al., 2013; Gans et al., 2019; McDonald and Eisenhardt, 2020; Camuffo et al., 2020, 2024; Contigiani et al., 2026) - Staging (dis)investments (Kogut, 1991; Bowman and Hurry, 1993; Kogut and Kulatilaka, 1994b; Kim and Kogut, 1996; Folta, 1998; Chi, 2000; Folta and Miller, 2002; McGrath and Nerkar, 2004; Fisch, 2008; Damaraju et al., 2015; Klingebiel and Adner, 2015; Belderbos et al., 2019; Ross et al., 2023) - Commitment vs flexibility (Gilbert and Lieberman, 1987; Ghemawat, 1991; Ghemawat and Del Sol, 1998; Kulatilaka and Perotti, 1998; Miller and Folta, 2002; Folta and O'Brien, 2004; Pacheco-de-Almeida et al., 2008; Hawk et al., 2013; Klingebiel and Joseph, 2016; Trigeorgis and Reuer, 2017) - Operational flexibility (Kogut, 1985; Kulatilaka, 1986; Sharp, 1991; Kogut and Kulatilaka, 1994a; Fisch and Zschoche, 2012; Trigeorgis and Reuer, 2017; Belderbos et al., 2020; Fisch and Puhr, 2022; Tvedt and Lunnan, 2025; Ma et al., 2026) - Resource management, reconfiguration, and erosion (Penrose, 1959; Helfat and Eisenhardt, 2004; Sirmon et al., 2007; Sakhartov and Folta, 2014; Le Breton-Miller and Miller, 2015; Rindova et al., 2016; Lieberman et al., 2017; Dickler et al., 2022; Ross et al., 2023; Ao et al., 2026) - Imitation (Haunschild and Miner, 1997; Lieberman and Asaba, 2006; Ethiraj and Zhu, 2008; Gaba and Terlaak, 2013; Ross and Sharapov, 2015; Ozmel et al., 2017; Giachetti and Torrisi, 2018; McDonald and Eisenhardt, 2020; Sharapov and Ross, 2023) - Firm boundaries and governance (Folta, 1998; Sutcliffe and Zaheer, 1998; Leiblein and Miller, 2003; Santoro and McGill, 2005; Brouthers et al., 2008; Kor et al., 2008; Cuypers and Martin, 2010; Leiblein et al., 2022a; Delios et al., 2025)	- Theory creation (Felin and Zenger, 2017; Zellweger and Zenger, 2023; Felin et al., 2024) - Shaping (Smith and Cao, 2007; Santos and Eisenhardt, 2009; Gavetti et al., 2017; McDonald and Eisenhardt, 2020; Pontikes and Rindova, 2020; Rindova and Courtney, 2020; Putra et al., 2026) - Imagination (Rindova and Martins, 2021, 2024) - Analogies (Gavetti and Rivkin, 2005; Carroll and Sørensen, 2024) - Framing contests (Kaplan, 2008) - Simple rules and heuristics (Busenitz and Barney, 1997; Davis et al., 2009; Bingham and Eisenhardt, 2011; Maitland and Sammartino, 2015; Sull and Eisenhardt, 2015; Ehrig et al., 2021; Gigerenzer et al., 2022; Reb et al., 2024) - Effectuation (Sarasvathy, 2001, 2024) - Unknown unknowns (De Meyer et al., 2002; Loch et al., 2006; Teece and Leih, 2016; Teece et al., 2016; Ehrig and Foss, 2022) - Randomization (Dushnitsky et al., 2023; Keyhani and Jamshidi, 2025)

Note: This table classifies the reviewed studies by the level of uncertainty they examine, clustered into themes. A theme's placement reflects the studies we reviewed, not the theme itself: imitation appears under L3 because the studies we cite address L3 uncertainty, not because imitation is confined to that level. Relatedly, a literature may span themes and levels: theory creation sits at L4, while theory-testing studies appear under experimentation at L3.

Level 1 uncertainty: A clear-enough future

The L1 uncertainty box contains most of what conventional strategy textbooks cover. Traditional strategy contributions, largely taught to students through classic strategy frameworks, are built on static assumptions (e.g., Ghemawat, 2016). For example, Porter's (1980) Five Forces takes a static perspective by looking at threats in the industry environment at a point in time. A forward-looking perspective assumes a firm can position itself to exploit predictable dynamic forces in the long term. The future is clear enough. Similarly, generic positioning strategies work best in stable environments, where firms take defensible positions (Bingham et al., 2011). The classic concept of the experience curve is traditionally assumed to be known ex ante and deterministic (Spence, 1981; Lieberman, 1984, 1987).¹⁰ Likewise, capabilities and routines work best in stable environments, whereas uncertain environments pose vulnerabilities (Le Breton-Miller and Miller, 2015). Finally, the traditional resource-based view (RBV) does not explicitly account for uncertain environments. It treats uncertainty as causal ambiguity (Mosakowski, 1997; Reed and DeFillippi, 1990). Furr and Eisenhardt (2021, p.1916) go further by arguing that RBV is relevant in low-uncertainty markets and in stable or mature industries with many established firms. They see "uncertainty as a critical boundary condition for RBV."

Level 2 uncertainty: Alternate futures

Strategy research that examines discrete, uncertain future states commonly focuses on technological states or political and government policy variables (e.g., Miller, 1998, 2002), as well as on competitive uncertainty in the context of alternative competitive moves (e.g., Ferrier, 2001). Often, the uncertainties of alternative discrete states can be assigned probabilities, and thus

¹⁰ Recent work relaxed this assumption by exploring the role of uncertainty in learning curves (Chen et al., 2023; Leiblein et al., 2023).

decision situations can be characterized as involving *risks*. It is also possible that under L2-uncertainty conditions, probabilities do not exist.

Discrete scenarios. Strategy-making with scenarios is one research area that builds on L2 uncertainty. This topic has received widespread attention from practitioners, with increased interest in recent years in both practice (Mangelsdorf, 2017; Graham, 2022)¹¹ and research (Feduzi et al., 2022; Healey and Hodgkinson, 2024). While scenario planning was initially more about the long term (e.g., Shell thinking far ahead), scenarios can inform shorter-term decisions (Schoemaker, 1993, 1995; Courtney, 2003). Field experiments show that using multiple discrete scenarios for long-range investments motivates field experts to recognize flexible options and use more flexible strategies (e.g., Phadnis et al., 2015). Scenario analysis can help develop alternative scenarios for the future trajectory of digital transformation by examining the interactions among shifts within and between technology, organization, and public policy spheres (e.g., Bodrožić and Adler, 2022). Belenzon, Bennett, and Pataconi (2019), for instance, develop four scenarios of capital-labor substitutability, then develop and empirically test a real-options model with flexibility strategies to address uncertainty.

Decision trees. Research on strategic decision-making under uncertainty using decision trees typically falls under L2 uncertainty. For instance, early conceptual works on real options that link finance and strategy in resource allocation use probabilities of alternative states to illustrate drivers of flexibility value (e.g., Trigeorgis, 1996). To consider the behavioral and organizational contexts of investment decisions, later strategy research has built on the assumption of having probabilities for uncertain outcomes and built on behavioral decision theory to develop a descriptive real-option theory that explains how heuristics and biases shape how managers value

¹¹ An *MIT Sloan Management Review* editorial director (Mangelsdorf, 2017) reports that Schoemaker's (1995) two-decade-old classic on scenario planning had suddenly reappeared among the journal's most-downloaded articles.

call and put options (e.g., Miller and Shapira, 2004). Building on rational arguments and the assumption of probabilities in decision trees, extensions of real-option theory with game theory in contexts such as innovation, alliances, and acquisitions have been used to explain strategic games and collaboration (Smit and Trigeorgis, 2017; Trigeorgis et al., 2022; Smit and Moraitis, 2026).

Competitive dynamics. Early empirical research on competitive dynamics uses game theory to examine discrete competitive decisions, i.e., whether and when a competitor responds to competitive actions. For example, Chen and MacMillan (1992) use variables that act as “surrogates” to estimate payoffs and probabilities in the action-response game. Traditional game-theoretic approaches assume that firms can create uncertainty for others (e.g., Dixit and Nalebuff, 1991). Later research on competitive dynamics builds on behavioral assumptions and finds that competitive actions can contribute to uncertainty by launching surprise moves (e.g., Ferrier, 2001) and by creating uncertainty through vague communications (Guo et al., 2017; Nadkarni et al., 2019). These actions matter for relative performance and help explain the likelihood of alternative futures, such as whether a competitor will respond. When facing uncertain outcomes about whether a regulatory body will approve a new product or technology, competition can motivate firms’ efforts to produce uncertainty-mitigating certifications in the battle for market dominance (Polidoro and Theeke, 2012; Polidoro, 2013).

Competing technologies and technology substitution. Technology competition is another area of strategy research that falls under L2 uncertainty. For instance, behavioral work examines how temporal and spatial myopia produce decision errors in acquiring, idling, and switching between technologies whose favorable/unfavorable states may revert (Miller, 2002), and simulation studies suggest that evolutionary and real-options logics can generate observationally similar investment patterns under uncertainty (Miller and Arikan, 2004).

Empirical work examines the drivers and consequences of risk-reducing strategies when known technologies compete during turbulent eras of ferment, including the consequences of bets on losing technologies (Tushman and Anderson, 1986; Eggers, 2012, 2016). These insights contribute to a larger research area that looks at “hedging” and parallel strategies under uncertainty in the context of technological discontinuities in emerging markets and industries (e.g., Hatfield et al., 2001), regulatory uncertainty (e.g., Gao and McDonald, 2022), input-cost uncertainty in technology substitution projects (Kulatilaka, 1993; Fisch and Ross, 2014), uncertain standards competition (Lint and Pennings, 2002; Smit and Trigeorgis, 2006a), and parallel development efforts with uncertain outcomes of competing approaches (Nelson, 1961; Abernathy and Rosenbloom, 1969; Roberts and Weitzman, 1981; Childs and Triantis, 1999).

Recent strategy research has renewed attention on alternative technologies amid uncertain environments with an increased explicit acknowledgment of uncertainty in ecosystem competition (e.g., Kapoor and Klueter, 2020, 2021), industry evolution (Moeen et al., 2020; Shermon and Moeen, 2022), and technology substitution, such as green technology transitions (Gans et al. 2021; Chen et al., 2023; Furr and Snow, 2024) or emerging geopolitical tensions and dependence on rare-earths supplies that have increased firm’s efforts to substitute materials (*New York Times*, 2025). The pace and uncertainty of technological change are likely to influence how firms reconfigure their capabilities (e.g., substitution, transformation, evolution; Lavie, 2006).

Level 3 uncertainty: A range of futures

In uncertain conditions, where a range of potential futures is considered, no natural discrete scenarios exist (Courtney et al., 1997). Future uncertain outcomes can vary across a continuous range. For instance, a company is about to enter a new geographic market but faces uncertainty in the domestic market. Analyses may reveal, with some confidence, lower and upper bounds on

demand, but actual demand remains unpredictable, creating uncertainty that can increase downside risks (Miller, 1992, 1998) and potentially increase organizational mortality rates (e.g., Anderson and Tushman, 2001). But it can also create opportunity (Kogut & Kulatilaka, 1994a; Kulatilaka & Perotti, 1998; McGrath and MacMillan, 2000; Folta, 2007) and positively influence firm performance (Oriani and Sobrero, 2008; Lee and Makhija, 2009; Levitas and Chi, 2010; Iouliauou et al., 2021; Dickler et al., 2022). Studies that build on L3 uncertainty outnumber those that build on L2 or L4 uncertainty. In the discussion, we reflect on why this difference occurs, but in Section 3, we focus on the topics investigated.

Wait-and-see. A stylized fact is that uncertainty motivates firms to delay their actions (Wernerfelt and Karnani, 1987; Rivoli and Salorio, 1996). This goes back to research in finance and economics that uncertainty and irreversibility, combined with the ability to delay, deter investment (McDonald and Siegel, 1986; Dixit and Pindyck, 1994), with robust empirical evidence for a negative uncertainty-investment relationship (for a review, see Carruth et al., 2000). So, what has research on strategic management under uncertainty contributed? First, the field has applied and tested related theories in various decisions providing empirical evidence in strategy-relevant decisions, such as market entry (Folta and O'Brien, 2004; Claussen et al., 2018), entrepreneurial entry (Folta et al., 2006; Wu and Knott, 2006), international expansion (Campa, 1993, 1994; Fisch, 2008), R&D investments (Ross and Fisch, 2018; Ross et al. 2018), investments in enabling complements (Toh & Agarwal, 2023), VC project initiation and withdrawal/exit (Li and Mahoney, 2011; Li and Chi, 2013; Li et al., 2025), resource idling and reactivation (Ross et al., 2023; Li and Ross, 2025), divestment (Belderbos and Zou, 2009; Damaraju et al., 2015; Song, 2024), industry exit (e.g., O'Brien and Folta, 2009), and market exit (e.g., Elfenbein and Knott, 2015).

Second, because the strategy field has long sought to understand the sources of firm heterogeneity (e.g., Rumelt et al., 1994), research has also explored the conditions that explain heterogeneity in decision-making and performance outcomes. Strategy research indicates that the negative relationship between uncertainty and investment/divestment is contingent on a firm's capabilities (Hawk et al., 2013; Claussen et al., 2018; Ross et al., 2018; Ross et al., 2023), a firm's strategy (e.g., O'Brien and Folta, 2009), and industry conditions (O'Brien et al., 2003; Folta and O'Brien, 2004). Overall, firm conditions play a crucial role in determining a firm's opportunity cost of waiting, investment thresholds, and the likelihood of benefiting from uncertainty's upside.

Third, strategy research on the timing of entry or exit decisions has also contributed to the larger phenomenon of *hysteresis* (e.g., Baldwin, 1989), defined as the "failure of an effect to reverse itself as its underlying cause is reversed" (Dixit, 1989, p.622). Hysteresis has received renewed attention in economics following the persistence effects observed after recent shocks (Göcke, 2002; Cerra et al., 2023; Dutt, 2023). While much of this attention concerns persistence at the aggregate level, research in business strategy, knowledge and innovation, corporate strategy, and global strategy contributes by examining the sources of firm heterogeneity in such persistence (Campa, 1993; Kogut and Kulatilaka, 1994b, 2001; Belderbos and Zou, 2009; Damaraju et al., 2015; Magliolo et al., 2020; Tvedt and Lunnan, 2025). Beyond providing insights on "why firms differ," this stream has also clarified "how firms behave" under uncertainty by distinguishing rational delay from managerial and organizational sources of inertia rooted in bias or uncertainty avoidance (Cyert and March, 1963; Staw, 1981).

Experimentation to learn and reduce uncertainty. A widely used approach to reducing uncertainty is low-cost probing to experiment and test the market (Sanchez and Sudharshan, 1993; Lynn et al., 1996; Brown and Eisenhardt, 1997, 1998; McGrath and MacMillan, 2000). When

uncertainty is high, little is known, and gaps are filled with assumptions that need validation and testing. Both discovery-driven planning (McGrath and MacMillan, 1995, 2009) and lean startup (Ries, 2011; Blank, 2013) offer methods to facilitate rapid learning and address uncertainty while keeping costs low. Strategy research has examined which firm-specific factors lower the costs of experimentation and enhance learning when facing uncertainty (Lieberman et al., 2017; Ross et al., 2018; Leatherbee and Katila, 2020; Contigiani et al., 2026), the benefits when experimenting to resolve uncertainty of strategic alternatives (Murray and Tripsas, 2004; Andries et al., 2013; Gans et al., 2019; Agrawal et al., 2021; Camuffo et al., 2024), the risk of imitation when experimenting under market uncertainty (e.g., Contigiani, 2023), and the cost of experimentation in the strategy context (Adner and Levinthal, 2024; Shelef et al., 2025).

Staging (dis)investments. In their classic article on strategy design for practicing managers, Hambrick and Fredrickson (2001) highlight staging as one of the five core elements of strategy, and maintain that to increase the likelihood of success of strategic moves, some initiatives must come first, followed by others. This staging relates to the speed and sequence of moves over time (Eisenhardt and Brown, 1998; Ferrier, 2001) as well as to the temporal interdependence of strategic decisions (Leiblein et al., 2018; Leiblein et al., 2022b). However, they also pointed out that at that time, “the concept of staging has gone largely unexplored in the strategy literature; it is often given far too little attention by strategists themselves” (Hambrick and Fredrickson, 2001, p.53).

While we agree with their general observation at that time, strategy research on decision-making under uncertainty *has* contributed to the staging issue. The discussion above of wait-and-see and more-active forms of reducing uncertainty through learning investments can motivate firms to defer full commitments and stage their investments (Kogut, 1991; Ghemawat and del Sol, 1998). Staging has been core to research on incremental investment under uncertainty to facilitate

learning and revealing additional information (Johanson and Vahlne, 1977; Roberts and Weitzman, 1981; Majd and Pindyck, 1987), reducing downside risks by maintaining flexibility, taking small investments or “stepping stones” (Sharp, 1991; Hurry et al, 1992; Bowman and Hurry, 1993; McGrath and MacMillan, 2000; Ott and Eisenhardt, 2020), and by investing in platforms for future expansion (e.g., Kogut and Kulatilaka, 1994b).

Empirical studies have explored this form of sequencing and incremental commitment, for instance in the context of R&D (McGrath and Nerkar, 2004; Klingebiel and Adner, 2015), platform technologies (e.g., Kim and Kogut, 1996), incremental modes of governance (Folta, 1998; Chi, 2000), equity purchases (e.g., Folta and Miller, 2002), capacity expansions (Pacheco-de-Almeida et al., 2008), international expansion (Fisch, 2008; Brouthers and Dikova, 2010; Belderbos et al., 2019), staged divestment (e.g., Damaraju et al., 2015), and partial idling (e.g., Ross et al., 2023).

Commitment vs. flexibility. Strategy research has also examined trade-offs in decision-making under uncertainty (Mitchell, 1989; Ghemawat, 1991; Folta and O’Brien, 2004; Hawk et al., 2013; Klingebiel and Joseph, 2016). This area of research is commonly linked to the tension between commitment to a certain “thrust” and flexibility to adapt or take advantage of uncertainty (e.g., Ghemawat and del Sol, 1998), which is a central concern in the timing of resource allocations under uncertainty (Trigeorgis and Reuer, 2017; Chi et al., 2019). Commitment serves as a countervailing force that mitigates the deferral effect of the hysteresis discussed earlier. Deferring an irreversible investment when facing uncertainty can have opportunity costs related to competitive preemption (Gilbert and Lieberman, 1987; Ghemawat, 1991; Folta and Miller, 2002; Miller and Folta, 2002; Folta and O’Brien, 2004; Smit and Trigeorgis, 2004, 2017) and network effects (e.g., Lin and Kulatilaka, 2007). Strategy research has identified managerial, organizational, and industry-level factors that determine when firms commit rather than defer their

decision and how these factors can shape the firm's upside of uncertainty (Ghemawat and del Sol, 1998; Kulatilaka and Perotti, 1998; Pacheco-de-Almeida and Zemsky, 2003; Oriani and Sobrero, 2008; Pacheco-de-Almeida et al., 2008; Alessandri et al., 2012; Posen et al., 2018; Bennett and Hall, 2020). Rare qualitative research that explicitly examines timing decisions under uncertainty corroborates the notion that decision makers are aware of the trade-off between uncertainty and premiums (Klingebiel and Joseph, 2016, p.1016). Overall, research on the strategic trade-off between commitment and flexibility has used the uncertainty context to show that firms self-select into entry timing, contributing to the broader strategy literature on entry timing (Lieberman and Montgomery, 1988; Suarez and Lanzolla, 2007; Klingebiel and Joseph, 2016).

Operational flexibility. Seminal IB studies have examined the roles of uncertainty and operational flexibility in creating firm value (e.g., Kogut, 1985). Multinational enterprises leverage operational flexibility in their network of foreign subsidiaries to adapt to shifting environments by expanding or contracting foreign operations (Fisch, 2008; Chung et al., 2010; Hanousek et al., 2021; Ma et al., 2026) and redeploying operations across markets to hedge against policy, local demand, or currency shocks (Kogut and Kulatilaka, 1994a; Petersen et al., 2000; Fisch and Zschoche, 2012). Operating flexibility through foreign diversification, which allows firms to shift activities across countries, is more valued in times of high uncertainty (Chang et al., 2016).

Resource management, reconfiguration, and erosion. Building on Penrose (1959), the resource management literature has integrated environmental uncertainty into the resource management process by structuring a firm's resource portfolio, bundling resources to construct or alter capabilities, and leveraging capabilities to create value (e.g., Sirmon et al., 2007). Research on resource redeployment finds that resource flexibility adds corporate value for multibusiness firms by enabling them to switch nonfinancial resources internally across their businesses

(Sakhartov and Folta, 2014, 2015; Lieberman et al., 2017). While uncertainty typically increases the value of redeployment and thus should induce redeployment, under very high uncertainty it can impede firms' ability to change (e.g., Ao et al., 2026). Recent research also explores the effect of rivals' competitive behavior as a boundary condition on the value created by more-reversible resource investments (Wibbens et al., 2025). Finally, uncertain environments expose vulnerabilities in different resources and capabilities (e.g., Le Breton-Miller and Miller, 2015), and potential capability loss can represent a sunk cost in (forward-looking) strategic decisions under uncertainty (O'Brien and Folta, 2009; Choi et al., 2018; Ross et al., 2023).

Imitate under uncertainty. Uncertainty has long been linked to imitation (Alchian, 1950; Haunschild and Miner, 1997; Henisz and Delios, 2001; Lieberman and Asaba, 2006; Rhee et al., 2006; Ethiraj and Zhu, 2008; Ross and Sharapov, 2015; Asaba and Lieberman, 2017; Ozmel et al., 2017; Giachetti and Torrissi, 2018; Oh and Barker, 2018; McDonald and Eisenhardt, 2020). While this relationship is generally assumed to be positive, some research provides evidence of a negative relationship (e.g., Gaba and Terlaak, 2013; for a review, see Posen et al., 2023), for instance, because uncertainty prevents effective imitation (Lippman and Rumelt, 1982). Others argue that imitation in the face of uncertainty provides legitimacy in uncertain environments (DiMaggio and Powell, 1983; Haveman, 1993), enables learning from others (Levitt and March, 1988; Baum et al., 2000), and economizes on search costs to reduce uncertainty (e.g., Cyert and March, 1963). Strategy research has found that imitation can effectively reduce downside risk when competing with rivals in uncertain environments, suggesting that uncertainty can motivate imitation to maintain the status quo (Ross and Sharapov, 2015; Sharapov and Ross, 2023).

Firm boundaries and governance. Uncertainty is also central to a firm's boundary decisions and governance choices (Williamson, 1985; Mahoney, 1992). For instance, research

building on transaction costs finds that technological uncertainty pushes firms to select market governance (e.g., alliances, contracts; Folta, 1998; Santoro and McGill, 2005), whereas behavioral uncertainty pushes them toward hierarchical modes of governance (Sutcliffe and Zaheer, 1998; Geyskens et al., 2006). Demand uncertainty positively affects vertical integration at high levels of asset specificity (e.g., Leiblein and Miller, 2003). Research has also established a relationship between uncertainty and ownership strategy (Folta and Miller, 2002; Kor et al., 2008; Cuypers and Martin, 2010; Li and Li, 2010; Tong and Li, 2011).

Level 4 uncertainty: True ambiguity

Strategy research is also increasingly contributing to managing uncertainty in which one cannot even define a range of futures (L4 box). Level 4 is distinguished not by the number of uncertain factors but by the depth of unknowability: even a single dimension, such as a genuinely novel technology or an unprecedented institutional change, can defy bounding. In practice, deep uncertainty often coincides with multiple, interacting uncertain factors, and such interactions can push a situation toward Level 4; we return to these configurations in Section 5.

The distinction between opportunity discovery and opportunity creation (Alvarez and Barney, 2007) helps characterize what sets Level 4 apart. Under discovery, opportunities exist independently of the actor and await recognition; the strategic problem is informational, and the outcome space, however wide, is in principle boundable. Under creation, opportunities do not preexist the actions that bring them about; the future is not merely unknown, it is not yet made, which is precisely why no range of outcomes can be defined. Indeed, the studies clustered under Level 3 in Table 2 predominantly reflect discovery settings, while those under Level 4 largely reflect creation settings. The correspondence is close but not complete: deep uncertainty can also be imposed exogenously, as when shocks unsettle a previously boundable environment (see Section 5). We therefore treat discovery and creation as characterizations of how actors relate to

uncertainty rather than as definitions of its levels. In this sense, choosing to create is choosing Level 4. Boards and executives may make that choice deliberately: Mastercard's appointment of Ajay Banga, hired for his vision of a cashless future, reflected a decision to embrace a Level 4 environment rather than wait for it to become boundable (Camuffo et al., 2026).

The distinction between discovery and creation also matters for how people interpret experimentation. In discovery settings, experiments are instruments of learning: they reveal information about an opportunity that exists to be found, which is the logic of staged options and of lean-startup testing. In creation settings, experimentation and stakeholder engagement do more than reveal. Commitments from customers, investors, and partners actively shape what the opportunity becomes, so that stakeholders participate in creating opportunities rather than merely evaluating them (Alvarez and Sachs, 2023; Alvarez et al., 2024). Under deep uncertainty, the same activity—an experiment, a pilot, an early sale—is thus simultaneously a measurement and a move.

Theory creation. How do actors act when no range of outcomes can be defined? One answer, developed through the theory-based view, is that they construct theories: firm-specific causal logics that generate the vision and the candidate scenarios that the environment does not supply (Felin and Zenger, 2017; Felin, Gambardella, and Zenger, 2024). Whereas discovery settings reward search, creation settings reward theorizing. This is because a good theory tells the actor what to imagine, which experiments would be informative, and which contrarian beliefs are worth betting on. Experimental evidence suggests this capability can be taught: entrepreneurs trained to frame their ventures as theories and test them scientifically make systematically different—and on average, better—decisions (Camuffo et al., 2020). The theory-based view thus bridges our levels: theories generate the scenarios that structure Level 3 and the visions that guide action at Level 4.

Shaping. Courtney, Kirkland, and Viguerie (1997) frame shaping as one approach to tackle this type of uncertainty, “bringing order to chaos” to coordinate the actions of other players and drive the market toward more stable outcomes. Significant symbolic and resource investments are intended to create new market orders, and poorly understood causal relationships are viewed as a source of opportunity (Pontikes and Rindova, 2020; Rindova and Courtney, 2020). Shaping environments has been part of strategy research (Gavetti et al., 2017; Helfat, 2021), including dynamic capabilities (Teece et al., 1997; Teece, 2007) and entrepreneurial actions in competitive dynamics (Smith and Cao, 2007; Rindova et al., 2010). Empirical work using qualitative data has examined nascent markets to shed light on how entrepreneurs shape nascent markets (Santos and Eisenhardt, 2009; McDonald and Eisenhardt, 2020; Gao and McDonald, 2022) and how incumbents navigate uncertainty when entering nascent ecosystems (e.g., Putra et al., 2026). A research area that contributes to the idea of shaping environments is related to imagination and focusing on what could be, e.g., through the use of narratives as a means to imagine alternative futures when facing uncertainty (Kaplan, 2008; Rindova and Martins, 2021, 2024) or through visionary scenarios (e.g., Courtney, 2003).

Analogies. In novel, uncertain environments, firms may also use analogies to avoid starting anew and delay fine-tuning until a market provides its guidance (Gavetti and Rivkin, 2005; Courtney et al., 2013; Carroll and Sørensen, 2024). In other words, the concrete nature of analogies provides conceptual quality that maintains flexibility for adaptation to unexpected situations. However, when knowledge and understanding are limited, the insights and predictive nature of analogies can pose dangers (e.g., Carroll and Sørensen, 2024).

Simple rules and heuristics. Strategy research has increasingly explored the role of heuristics in strategic management under uncertainty. The broader literature on heuristics can be

structured in three areas (for reviews, see Vuori et al., 2024, and Bingham and Eisenhardt, 2025): heuristics and biases (e.g., Tversky and Kahneman, 1974), fast-and-frugal heuristics (Mousavi and Gigerenzer, 2014; Gigerenzer et al., 2022), and simple-rule heuristics (Bingham and Eisenhardt, 2011; Sull and Eisenhardt, 2015). These three views on heuristics share common features: they reduce cognitive effort in decision-making, enable faster decision-making, and apply in situations characterized by uncertainty and complexity (Vuori et al., 2024). While these three streams build on Simon's (1955) research on decision-making under limited information, they contribute differently to research on strategic management under uncertainty. For instance, heuristics and biases can serve as decision-making shortcuts in uncertain environments, and entrepreneurs and managers vary in how much they use them (e.g., Busenitz and Barney, 1997). Research on simple rules builds on informal rules of thumb that multiple participants within an organization learn and share. This research emerged from the study of companies operating in high-velocity, uncertain environments that seek to capture fleeting opportunities and grow (Davis et al., 2009; Bingham and Eisenhardt, 2011; Maitland and Sammartino, 2015). Research on fast-and-frugal heuristics seeks to enable rather than limit strategic decision-making under uncertainty by ignoring information “to make decisions more quickly, frugally, and/or accurately than complex procedures” (Gigerenzer et al., 2022, p.172). This stream introduces the concept of ecological rationality and specifies the environmental conditions under which each heuristic works well.

Effectuation. This approach is useful when prediction is not possible, such as in non-existent markets with multiple uncertainties (e.g., Sarasvathy, 2024). Effectuation focuses on selecting from possible effects that can be created (e.g., in cooperation with others) with a given set of means, and on the controllable aspects of an unpredictable future—rather than predicting it, the underpinning logic is to control it (Sarasvathy, 2001; Wiltbank et al., 2006).

Unknown unknowns. The L4 box includes research on unknown unknowns. “It is not just that probabilities for an event are unavailable—rather, the event is not even anticipated or imagined and therefore not ex ante categorized, discussed, etc. by decision makers” (Ehrig and Foss, 2022, p.7). While project management literature provides insights into managing unknown unknowns in projects (De Meyer et al., 2002; Loch et al., 2006), the strategy literature on this topic is emerging (Bryan et al., 2022; Ehrig and Foss, 2022; Ehrig and Schmidt, 2022). Teece and colleagues (Teece et al., 2016; Petit and Teece, 2021) suggest that the dynamic-capabilities framework, which empirical research most often deploys under bounded uncertainty, can guide managers on when and how to manage deep uncertainty (“unknown unknowns”). One approach to organizational decision-making under extremely high uncertainty and unknown unknowns is *randomization* (e.g., Dushnitsky et al., 2023) and random experimentation, which emphasizes diversification over learning in dealing with entrepreneurial uncertainty (e.g., Keyhani and Jamshidi, 2025).

4. Strategy Toolbox for Strategic Management Under Uncertainty

The literature above addresses different levels of uncertainty and provides tools to tackle strategic management under uncertainty. In Table 3, we list these tools accordingly. Some of these tools did not originate in strategy per se, but they have been shown to address strategy problems. Hence, we call them here strategy tools for different levels of uncertainty.

Table 3: Strategy Tools for Different Levels of Uncertainty

Level 1 uncertainty	Level 2 uncertainty	Level 3 uncertainty	Level 4 uncertainty
- Conventional market research - SWOT - Ansoff Matrix - Cost benchmarking - Core competences; capabilities; RBV - Generic strategies - Five Forces - BCG growth/share matrix - Experience curve - DCF/NPV calculations	- Decision trees - Decision trees with real options - Discrete scenarios - Game theory - Game theory with discrete scenarios - Competitive dynamics - Business war-gaming - Real options for discrete alternatives - Real options and games - Monte Carlo simulation - Bayesian updating* - Dynamic capabilities* - Strategic risk management	- Scenarios for a range of futures* - Latent demand research - System dynamics - Business simulation - Real options* - Experimentation - Probe and learn - Discovery-driven planning - Lean-startup toolkit, e.g., • Build-measure-learn • MVP • A/B testing • Pivoting - Dynamic capabilities*	- Analogies - Simple rules and heuristics* - Randomization - Effectuation* - Imagination/vision - Theory-based view* - Shaping*

Note: Placement indicates the home level, i.e., the dominant application in our reading; entries marked with an asterisk span adjacent levels (see Section 3).

Our sorting of strategy tools by levels of uncertainty, as we did with the strategy research in Section 3, provides a starting point for Ghemawat’s (2016) suggestion to sort through strategy frameworks to identify (dynamic) frameworks useful to managers. Ghemawat’s (2002, 2016) reflections on the evolution of practical ideas about business strategy using 81 strategy frameworks classified by the Boston Consulting Group focus on the distinction between static and dynamic frameworks and their evolution. Ghemawat argues that *uncertainty* should be treated as one of the “markers of particular strategic interest in a dynamic context” (Ghemawat, 2016, p.745) and as a criterion for assessing the potential of practical ideas about strategy for managers in such contexts.

5. Transitions, Dynamics, and Interactions

Transitioning between uncertainty levels

The L1–L4 boxes are not static. New entrepreneurial firms often start in the L4 box, but transition over time toward the lower-level boxes as uncertainties are resolved through passive or active learning (e.g., Courtney, 2001). Environmental shifts, industry shocks, and disruptions can

also affect *uncertainty transitions*, typically by temporarily increasing uncertainty levels (see Figure 1 and Table 4).

Defining decision-making under uncertainty as an entrepreneurial process, Packard, Clark, and Klein (2017, p.850) point out 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.” Hence, over time, two types of transitions occur: either toward lower uncertainty (toward risk) or toward higher uncertainty. This dynamic process shows how entrepreneurs and firms respond to changing uncertainty conditions. Gao and McDonald (2022) explore an empirical example of navigating regulatory uncertainty. While the strategies of firms can differ based on the degree of uncertainty assumed by firms and their actions, regulatory uncertainty can change over time, motivating different approaches in different phases, such as multiple hedges to counteract downsides, probing to generate information while learning is still possible, or shaping efforts in a co-creation process for new regulatory frameworks. As markets mature, firms transition from experimentation to VRIN-based strategies to compete successfully (Davis et al., 2009; Furr and Eisenhardt, 2021; Tidhar et al., 2025).

Table 4: Research That Spans Levels of Uncertainty

Broad Area	Specific Topic	Sources	Integration
Transitioning between uncertainty levels (over time)	Uncertainty transitions	Davis et al. (2009); Packard et al. (2017); Gao and McDonald (2022)	As environmental shifts occur, the nature of uncertainty may return to higher levels, pushing actors to reopen their sets of outcomes or options.
	Experimentation	McGrath and MacMillan (1995, 2000, 2009)	Experimentation reduces the level of uncertainty.
	Industry evolution	Moeen and Agarwal (2017); Moeen et al. (2020)	As the industry evolves, actors face different levels of uncertainty.
	Technology transition	Tushman and Anderson (1986); Furr and Snow (2024)	Technological discontinuities and substitution can increase and reduce uncertainty.
	Exogenous shocks as forced transitions	Easley (2016); Eberhart et al. (2017); Wu et al. (2022)	Exogenous shocks can force rapid shifts across uncertainty levels.
	Incremental/staged decisions	Roberts and Weitzman (1981); Bowman and Hurry (1993)	An option chain unfolds as a series of interwoven small and large investments that reduce uncertainty over time.
	Growth staircases	Conn and McLean (2018)	This step-by-step approach aligns with the level of uncertainty, expanding commitment as uncertainty decreases.
	Shaping	Courtney et al. (1997); Rindova and Courtney (2020)	A “shaper” (alone or in collaboration with others) can bring “order to chaos” by reducing uncertainty (e.g., from L4 to L3).
	Collective uncertainty reduction	McCarter et al. (2011)	Multiple alliance partners reduce social uncertainty collectively.
Multiple uncertainties	Existence of multiple uncertainties	Anderson and Tushman (2001)	For example, the coexistence of technological and demand uncertainty influences exit decisions.
	Parallel experimentation	Roberts and Weitzman (1981); Andries et al. (2013); Gans et al. (2019); Chavda et al. (2024)	Parallel experimentation can help reduce multiple uncertainties.
	Assumption testing	McGrath and MacMillan (1995); Fjeld (2018)	Entrepreneurs test various assumptions, yet the sequence should be prioritized to be more cost-effective.
	Temporality of uncertainties	Posen et al. (2018)	The authors augment real-option theory’s focus on uncertain future asset values (prospective uncertainty) with feedback learning theory that considers uncertain current asset values (contemporaneous uncertainty).
	Exogenous and endogenous uncertainty require different tools	Augier et al. (2018)	For example, firms use scenario analysis to tackle exogenous uncertainty but use war-gaming when facing endogenous uncertainty.
	Figuration	Rindova and Martins (2021)	Figuration enables firms to address uncertainties about the future by selectively highlighting specific uncertainties and proposing solutions to them through their futurescapes.
Interactions of uncertainties (at one point in time or over time)	Interrelated uncertainties and uncertainty trade-offs	Miller (1992, 1998); Miller and Waller (2003)	Reduction of uncertainty in one dimension may result in increased exposure to another uncertainty.
	Interactions of different uncertainties	Smit and Trigeorgis (2004, 2017); Rindova et al. (2010); Pisano (2017) ; Smit et al. (2017); Posen et al. (2018); Moeen et al. (2020); Kapoor and Klueter (2021)	Interactions of uncertainties play an important role in evaluating opportunities and allocating resources.

	Correlation between uncertainties	Vassolo et al. (2004); Anand et al. (2007); Van Bekkum et al. (2009); Fisch and Zschoche (2012); Fisch and Ross (2014); Song (2024); Li et al. (2025)	These studies focus on the role of correlation between uncertainties as an environmental property and its effect on an independent variable (e.g., the value of an investment opportunity).
	Multidimensional conceptualization of environmental velocity regimes	McCarthy et al. (2010)	Velocity regimes are associated with different rates and directions of change across environmental dimensions.
	Polycrisis	Klyver and McMullen (2025)	Polycrisis distinguishes itself from market uncertainty during single-crisis events by the number of overlapping and entangled unknowns and the degree of their unknowability.
Portfolios of uncertain initiatives	Portfolio decisions	Vassolo et al. (2004); Anand et al. (2007); Girotra et al. (2007); Belderbos and Zou (2009); Li and Chi (2013); Belderbos et al. (2020); Trigeorgis and Miller (2026)	Interdependencies complicate the portfolio management problem.
	Managing option portfolios	Luehrman (1998); McGrath and MacMillan (2000); Smit and Trigeorgis (2006b)	The firm's options fit into different uncertainty categories.
	Market opportunities: Backup and growth options	Gruber and Tal (2017)	Amid high market uncertainty, a portfolio with backup and growth options in addition to the primary market opportunity helps balance the tension between focus and flexibility.
	Ambidexterity; Exploration/exploitation	Posen and Levinthal (2012); O'Reilly and Tushman (2013)	It's hard to manage businesses with different levels of uncertainty simultaneously.
Sensing	Scenario analysis	Schoemaker (1995, 2022); Courtney (2003)	Scenario analysis identifies relevant uncertainties.
	Sensemaking and recognition of shadow options	Bowman and Hurry (1993); Hurry (1994); Barnett (2008); Andriani and Cattani (2024)	The recognition and conversion of shadow options into real options is based on sensemaking.
	Dynamic capabilities	Teece (2007); Teece et al. (2016)	Sense and seize options transform a firm in situations with deep uncertainty.
Matching your strategy approach to the environment	Emergent vs. deliberate strategic planning	Mintzberg and Waters (1985); Grant (2003)	Unpredictable environments call for greater use of emergent strategies.
	Prediction and control	Wiltbank et al. (2006); Reeves et al. (2015); Packard and Clark (2020)	Maps connect strategy tools to the environment, emphasizing prediction vs. control of environmental conditions.
	Strategic logics	Bingham et al. (2011); Eisenhardt and Bingham (2017); Furr and Eisenhardt (2021)	Market maturity (with declining uncertainty) determines the transition between strategic logics.
	Design-based vs. theory-based approach	Gambardella and Messinese (2025)	The design-based approach helps gather information to shape the environment, whereas the theory-based approach helps pursue high performance under lower degrees of uncertainty.
	Ecological rationality	Gigerenzer et al. (2022)	Ecological rationality is the study of the environmental conditions under which a given heuristic performs better than other strategies.
	Decision support tools	Courtney (2001); Courtney et al. (2013)	The use of a decision-making tool depends on how well the variables that determine success are understood, how well one can predict the range of possible outcomes, and how centralized the relevant information is.

The idea of transitioning between uncertainty levels relates to several broad frameworks in strategic management research. One is the *industry evolution* framework, in which actors face unknown unknowns (L4) at the onset of industry incubation and later shift to deepen their understanding or address specific dimensions of uncertainty (Moeen et al., 2020, p.237). Industry evolution is driven by active and passive learning at the firm and industry levels that tends to reduce uncertainty. However, movements often occur in the opposite direction during *technology transitions*, when technological upheaval can increase uncertainty (e.g., Tushman and Anderson, 1986). Alternatively, when the rate of technical change is gradual, technological substitution can push firms leftward in our framework due to endogenous (e.g., investment, effort) or exogenous factors (e.g., institutional forces) (Furr and Snow, 2024). Similarly, research on institutional change shows how regulatory reforms can paradoxically increase or decrease uncertainty in nonobvious ways (Eberhart et al., 2017; Wu et al., 2022). Other types of policy shocks tend to push established industries rightward, from L1/L2 to L3/L4—essentially forcing mature sectors to operate under higher-uncertainty regimes.

As shown in Table 4, proposed strategy approaches related to uncertainty transitions include *experimentation* to test assumptions and reduce the level of uncertainty (McGrath and MacMillan, 1995, 2000, 2009), *incremental/staged decisions* to reduce uncertainty facilitated by option-chains as a series of interwoven small and large investments (Roberts and Weitzman, 1981; Bowman and Hurry, 1993), and *growth staircases*, defined as a step-by-step approach that corresponds to shifts in uncertainty level and expanding commitment as uncertainty is reduced (e.g., Conn and McLean, 2018). As noted earlier, another strategy approach linked to uncertainty transitions is *shaping* (Courtney et al., 1997; Rindova and Courtney, 2020). For instance, a “shaper” (alone or in collaboration with others) can bring “order to chaos” by reducing uncertainty

(e.g., transitioning from L4 to L3). Shaping highlights a broader point: the level of uncertainty a firm faces is partly an outcome of its own strategic choices. A firm's theory of how it will create value offers a blueprint for its shaping efforts (Felin et al., 2024). Firms differ systematically in the level they elect to engage. Visionary leaders and ambitious innovators can pull their firms into Level 4 arenas, whereas accountability to diversified stakeholders and the need to present evidence-based justification for decisions pull firms toward Levels 1 and 2, where data exist and probabilities can be estimated. Uber's regulatory strategy (see the vignette in Section 2) illustrates such shaping in practice. Collective approaches to reducing uncertainty through strategic alliances can also help manage social uncertainty (e.g., McCarter et al., 2011).

Overall, Table 4 suggests that uncertainty transitions can take distinct forms, such as learning-driven (e.g., endogenous and exogenous learning within a process of industry evolution), shock-driven (e.g., disruptive technologies, regulatory changes, and pandemics), and deliberate shaping (e.g., Uber's regulatory strategy). These transitions can shift firms and industries leftward or rightward in our framework.

Multiple uncertainties

Most strategy research on uncertainty focuses on a single type. While this approach has helped our understanding of strategy decision-making under uncertainty, it can also mask the effect that firms face multiple uncertainties at a point in time. For instance, technological and demand uncertainties coexist during technological transitions, creating L2 and L3 uncertainty (Anderson and Tushman, 2001). Nevertheless, entrepreneurs and managers can face portfolios of uncertainties across all four levels simultaneously—technology uncertainty (L3/4), competitive uncertainty (L2), demand uncertainty (L2/3), regulatory uncertainty (varying levels), etc. For

instance, work on institutional intermediaries (e.g., Armanios et al., 2017) showed that entrepreneurs in emerging economies navigate multiple sources of uncertainty simultaneously.

Research on *parallel experimentation* points to the parallel resolution of different sources of uncertainty (Roberts and Weitzman, 1981; Andries et al., 2013; Gans et al., 2019; Chavda et al., 2024). Through parallel experimentation, entrepreneurs discover alternative ways to execute a business idea and learn about the environment's properties and the most promising opportunities within it. This approach closely relates to *assumption testing*, in which smart planning (in parallel or in sequence) can help resolve multiple uncertainties at lower cost (McGrath and MacMillan, 1995; Fjeld, 2018). Strategy research on the temporality of uncertainties has also shown that decision-making can be influenced by simultaneous, contemporaneous, and prospective uncertainties, with implications for the theories that need to be considered and for decision-making errors if ignored (e.g., Posen et al., 2018).

Indeed, multiple uncertainties can create challenges, as decisions must be made about which to address, and when. Facing multiple uncertainties of distinct natures also requires a different selection of strategy tools to address them simultaneously. For example, while scenario analysis can help tackle exogenous uncertainty (Schoemaker, 2002; Miller and Waller, 2003), war-gaming helps address endogenous uncertainty; combining the two helps address both simultaneously (e.g., Augier et al., 2018). In the face of uncertainty and ambiguity, *figuration* emphasizes different uncertainties about the future and addresses distinct types of uncertainty (e.g., Rindova and Martins, 2021). It selectively highlights specific uncertainties and proposes solutions through futurescapes (i.e., distinct future landscapes or worlds).

Interactions of uncertainties

Building on earlier elaborations of multiple uncertainties, firms also face uncertainties that interact at a point in time. Miller (1992, 1998) has noted that firms face interrelated uncertainties

and *trade-offs*. For instance, reducing one uncertainty dimension may increase exposure to another source of uncertainty. A rich set of studies has explored the implications of *interactions of different uncertainties* for evaluating opportunities, allocating resources, and evaluating decision outcomes (Smit and Trigeorgis, 2004, 2017; Rindova et al., 2010; Pisano, 2017; Smit et al., 2017; Posen et al., 2018; Moeen et al., 2020; Packard and Clark, 2020). For instance, Kapoor and Klueter (2021) emphasize that identifying interactions matters for managing uncertainty, as interactions among uncertainties affect which sources of uncertainty to address first and how to allocate resources across sources over time. This study also highlights that a structured approach to unbundling the different sources of uncertainty and recognizing their interactions can provide a basis for firms to develop superior sensing and seizing capabilities. Interactions among uncertainties may be an important opportunity to advance the theoretical perspective on dynamic capability.

However, some empirical research finds no statistically significant interaction effect between uncertainties on the dependent variable (Sutcliffe and Zaheer, 1998; Lee and Makhija, 2009). To shed light on conditions with multiple interacting uncertainties, studies may examine the temporal stability of exposure coefficients of interrelated uncertainties (e.g., Miller, 1998) or build on multidimensional concepts to create *environmental velocity regimes* that are characterized by different rates and directions of change across dimensions (e.g., McCarthy et al., 2010). These interactions also bear on the levels framework itself. As noted in Section 3, the number of uncertain factors does not define deep uncertainty; rather, interactions among factors can render the joint outcome space unboundable, pushing a situation toward Level 4 even when each source, taken alone, sits at Level 2 or 3. Recent debates on *polycrisis* illustrate this escalation and warrant attention from strategy research. Creating institutional uncertainty appears different from single-crisis or market uncertainty as (1) the number of unknowns increases, (2) uncertainty related to the

social domain (not just the economic domain) is involved, and (3) a range of unpredictable factors are interrelated (e.g., Klyver and McMullen, 2025).

In polycrisis situations, shocks occur simultaneously, creating correlation between uncertainties. However, despite its conceptual relevance for resource-allocation decisions and risk profiles more broadly, only a limited amount of research in strategy, innovation, and IB has looked at *the correlation between uncertainties* (Goldberg and Kolstad, 1995; Lint and Pennings, 2002; Vassolo et al., 2004; Anand et al., 2007; Van Bekkum et al., 2009; Fisch and Zschoche, 2012; Fisch and Ross, 2014; Belderbos et al., 2020; Song, 2024; Li et al., 2025).

Note that both correlation and interaction can be easily conflated. While an interaction examines the moderating effect of one uncertainty (e.g., transactional uncertainty) on the direct effect of another uncertainty (e.g., economic uncertainty) on a dependent variable (e.g., Smit et al., 2017), a correlation examines whether the uncertainties move in similar directions. For example, a firm's operating flexibility enables it to shift production across borders when labor cost uncertainties in different markets are negatively correlated (Fisch and Zschoche, 2012; Belderbos et al., 2020). While negative correlation between uncertain assets is commonly viewed as reducing risk, some research also emphasizes the role of positive correlation between uncertainties for effective diversification in R&D (Van Bekkum et al., 2009; Goldenberg, 2010; Fisch and Ross, 2014). This effect seems to depend largely on the conditionality/option-like risk of investments and project maturity (Van Bekkum et al., 2009).

Portfolios of uncertain initiatives

In response to multiple sources of uncertainty, firms hold and adjust their portfolio of uncertain initiatives. Because these initiatives target different uncertainties and/or are at different maturity levels, they can be placed independently in different L1–L4 boxes, but together they

create a function for the firm's portfolio (e.g., diversification, hedging). Strategy research has examined various *portfolio decisions* under uncertainty (Anand et al., 2007; Girotra et al., 2007; Belderbos and Zou, 2009; Li and Chi, 2013; Belderbos et al., 2020; Trigeorgis and Miller, 2025). For instance, interdependencies across uncertain initiatives can influence R&D portfolio decisions (e.g., Vassolo et al., 2004). Strategy research also offers approaches for *managing option portfolios* to address resource allocation under uncertainty. Portfolio approaches focus on option selection and exercise (e.g., Luehrman, 1998), multiple uncertainties in option portfolios (McGrath and MacMillan, 2000; MacMillan and McGrath, 2002), and competitive effects when managing option portfolios (e.g., Smit and Trigeorgis, 2006b). Relatedly, Gruber and Tal's (2017) entrepreneurship framework builds on real options to inform the selection of market opportunities, suggesting that holding a portfolio under high market uncertainty, with backup and growth options in addition to the primary market opportunity, helps balance the tension between focus and flexibility.

The broader challenge of searching among uncertain alternatives also relates to balancing *exploration and exploitation* (Levinthal and March, 1981; March, 1991) and organizational ambidexterity (e.g., O'Reilly and Tushman, 2013). Mature companies often struggle to create new businesses in Levels 3 and 4 without resorting to acquisitions. Environmental turbulence can affect the relative mix of exploration and exploitation, with exploration becoming more valuable at intermediate uncertainty levels (e.g., Posen and Levinthal, 2012).

Sensing

Sensing of unknown futures is a feature of *dynamic capabilities*. Teece, Peteraf, and Leih (2016, p.21, italics original) point out that in “environments characterized by deep uncertainty, companies must sense and/or generate options for growth *before* the market logics of those options become apparent to all. The set of capabilities to achieve this outcome includes *generative sensing*,

sensemaking, use of scenario planning, and the ‘purchase’ of real options.” Generative sensing helps reflect on future implications of trends and events. *Sensemaking* is the process of recognizing and converting shadow options into real options (Bowman and Hurry, 1993; Hurry, 1994; Barnett, 2008; Andriani and Cattani, 2024). *Scenario planning* maps plausible futures and identifies uncertainties in the organization’s environment (Schoemaker, 1995; Miller and Waller, 2003). It can assess different levels of uncertainty (e.g., L2–L4 uncertainty; see Courtney, 2003). Such probing efforts can help us learn about the future and uncover vulnerabilities of the previously unknown (Lynn et al., 1996; Brown and Eisenhardt, 1997).

Matching your strategy approach to the environment

Extant works provide guidance on the fit between strategy approaches and environmental conditions. Shifting environments or attention to different issues require adjustments to the strategy approach. Seminal works on *deliberate strategic planning vs. emergent process* schools of strategy argue that an unpredictable environment calls for greater reliance on emergent strategy (Mintzberg and Waters, 1985; Grant, 2003). Strategy research on predictive vs. nonpredictive strategies has mapped different strategy approaches by separating them along dimensions of *prediction and control* (Wiltbank et al., 2006), and it provides normative recommendations regarding which environmental conditions must exist to select a specific strategy approach (Reeves et al., 2015; Packard and Clark, 2020). Research on *strategic logics* (i.e., positioning, leverage, opportunity) argues that unpredictability and dynamic environments are features of opportunity logic and strategy creation, whereas leverage logic is better for settings with predictably changing markets and position logic suits stable, established markets (Bingham et al., 2011; Eisenhardt and Bingham, 2017; Furr and Eisenhardt, 2021). More recent research on *design-based vs. theory-based approaches* to strategic decision-making under uncertainty suggests that the former suits

ventures seeking to shape their environment, whereas the latter suits achieving high performance under lower degrees of uncertainty (e.g., Gambardella and Messinese, 2025). Research on *ecological rationality* examines the environmental conditions under which a given heuristic outperforms other strategies (e.g., Gigerenzer et al., 2022). Examples of such heuristics for strategic decision-making include various forms of strategic imitation that need to match environmental conditions to be effective (Haunschild and Miner, 1997; Sharapov and Ross, 2023).

Finally, strategic decisions may also need to match the *decision support tool*. While many decision makers rely on a single tool or follow decision rules that don't fit all environmental conditions (e.g., Graham, 2022), the available toolkit for strategic decision-making is diverse, and thus the decision support tool should be selected based on the situation at hand, such as “how well you understand the variables that will determine success, how well you can predict the range of possible outcomes, and how centralized the relevant information is” (Courtney et al., 2013, p.65). Table 3 helps facilitate this matching process.

6. Potential Directions for Future Research

Despite the rich literature on strategic management under uncertainty, significant opportunities remain for further research. In general, we see many opportunities to further flesh out the dynamics that shift firms across uncertainty levels and to provide managerial guidance for dealing with the challenges that arise. The ideas below are not meant to be conclusive, but rather to enable continuing discussion and debate.

Exogenous shocks and crises as forced transitions. Shocks and crises, such as COVID-19, can rapidly shift uncertainty levels and introduce new uncertainties. Regulatory reforms, institutional shocks, and policy shocks can also shape uncertainties in nonobvious ways. We see continuing research opportunities to expand our understanding of how different types of

institutional shocks move firms across uncertainty levels, and how firms that recognize these transitions early can position themselves for advantage.

Multiple uncertainties in real contexts. Research opportunities remain regarding how successful entrepreneurs and managers prioritize among uncertainties at different levels, how addressing one uncertainty level can create cascading effects at other levels, and how portfolio approaches map onto the four-level framework. Crises, such as wars and pandemics, can also increase the portfolio of uncertainties in a relatively short time period. We lack research on how the strategic management of uncertainty in polycrisis situations differs from single-crisis situations (e.g., Klyver and McMullen, 2025).

Exogenous versus endogenous resolution of uncertainty. Much of the strategy and real-options literature draws on finance assumptions of exogenous uncertainty resolution. These studies assume that uncertainty reduces over time. But even when uncertainty reduction appears exogenous to a focal firm, it typically reflects prior endogenous actions by others. In most business settings, uncertainty is reduced only after certain actors undertake actions that actively resolve it. Yet once those actors reduce uncertainty, its reduction appears exogenous to others in the field. A given industry may consist of different types of firms: those that invest in resolving uncertainty, and those that respond once it has been reduced. Their strategic approaches can diverge significantly, and their success can depend on their strategy. In some contexts (e.g., where organizational learning can be kept proprietary), it may be better to invest in reducing uncertainty, whereas in other contexts (e.g., where mimetic learning is comparatively easy for firms that invest in absorptive capacity), it is better to be a follower. It would be insightful to better understand how firms differ in their strategies for resolving uncertainty, and when these strategies are most

successful. A related question is when experimentation functions as learning about an opportunity and when, through the stakeholder commitments it mobilizes, the firm participates in creating one.

The choice of uncertainty level. While our review highlights how firms behave once positioned at a given level of uncertainty, it is equally vital to explore how firms arrive at a level: why do some organizations deliberately enter Level 4 arenas while others confine themselves to conditions where evidence and probabilities are available? Governance arrangements, incentive systems, leadership vision, and capability endowments are possible explanations. Firms may avoid deeper uncertainty not by preference but because they lack protocols for handling it, which connects the choice of level to the diagnostic gap discussed above and to the teaching agenda in our conclusion. Examining the choice of level, alongside behavior within levels and transitions between them, would enrich research on the strategic management of uncertainty.

AI as a strategic enabler and research tool. As AI capabilities continue to advance, there is an emerging opportunity to examine how AI might influence both the practice and the study of strategic decision-making under uncertainty (Camuffo et al., 2023; Csaszar et al., 2024; Felin and Holweg, 2024; Townsend et al., 2025; Allen and McDonald, 2026; Stuart, 2026). On the practice side, AI could enhance managers' ability to diagnose uncertainty levels, simulate scenarios more effectively, or detect early signals of uncertainty transitions. However, it remains to be explored at what level of uncertainty algorithms and automation dominate humans (and vice versa). One conjecture our framework suggests is that the comparative advantage of algorithms declines along the continuum: AI should dominate where uncertainty is calculable from data (Levels 1 and 2), remain useful for mapping ranges (Level 3), and cede ground to human judgment where the outcome space itself cannot be bounded, and thus offers no distribution to learn from (Level 4). AI tools could enable more sophisticated analysis of how firms navigate multiple uncertainties

simultaneously; for instance, using large language models to analyze strategic communications across thousands of firms experiencing institutional shocks, or using machine learning to identify patterns in how entrepreneurs sequence their responses to different uncertainty types. The interplay between AI capabilities and our four-level framework seems ripe for exploration.

Cross-context learning and tool translation. Our four-box framework implies that tools developed for one uncertainty level should work similarly across contexts, but translation challenges may require further research with relevance for business practice and teaching. For instance, lean-startup methods (designed for L3/4 entrepreneurship) often assume institutional infrastructure that does not exist in emerging markets. Scenario planning (L2/3) requires data and analytical capacity that vary enormously across settings (e.g., due to a lack of infrastructure and education). Overall, this points to the need for research on how uncertainty management tools must be adapted across institutional contexts.

Measurement of uncertainty. Though various sources exist to help guide researchers and managers on how to measure uncertainty and distinguish it from different forms of environmental variations (Downey and Slocum, 1975; Milliken, 1987; Wholey and Brittain, 1989; Folta, 2005; Miller et al., 2006; Bloom, 2014), the selection of the right measure for the problem at hand has to be taken with care. For instance, developers of the economic policy uncertainty (EPU) index recently noted that different publicly available measures yielded different estimates of the level of uncertainty in 2025 (Ahir et al., 2025). Uncertainty about whom, over what, and for what time period is an important feature for the measurement. We submit that there is room for a renewed article on research methods on this topic.

The metacognitive capability gap. As noted in the introduction, consulting studies find that most firms fail to match their strategy approach to environmental uncertainty—they know the tools

but apply them incorrectly or not at all. Beyond biases and inertia toward certain approaches, we maintain that the underpinning capability remains underexplored: How do managers develop the ability to diagnose the level of uncertainty they face? This connects to entrepreneurial learning across uncertainty transitions, organizational capabilities for sensing uncertainty transitions (e.g., Teece et al. 2016), and the pedagogical challenge of teaching uncertainty recognition rather than just uncertainty management. Our framework treats L2 (alternate futures) and L3 (range of futures) as distinct, but in practice, they often blur. The distinction between using one tool over another (see Table 3) rests on whether futures are discrete or continuous, but real situations often have elements of both, creating fuzziness. Future research could examine how managers make this diagnostic call in ambiguous situations.

Practitioner usage of tools. Taking this argument a step further, academics have an opportunity to help bridge the gap between the extensive theoretical work described in this paper and the limited practitioner application of tools for managing uncertainty. This problem seems particularly acute in large firms that tend to rely on classic strategy frameworks but struggle when facing environmental change. Consultants can play a facilitating role but may need to become more conversant with the frameworks discussed in this paper. Collaboration among consultants, academics, and practitioners would be ideal to make progress here.

7. Conclusion: Uncertainty as a Thread, and an Opportunity for the Strategy Field

Almost 60 years ago, Thompson (1967, p.159) argued that “uncertainty appears as the fundamental problem for complex organizations, and coping with uncertainty, as the essence of administrative processes.” Three decades later, Rumelt, Schendel, and Teece (1994) identified uncertainty as one of the “conceptual monkey wrenches” in the strategic management field. Since then, many studies have advanced our knowledge of the strategic management of uncertainty. Yet

as the strategic management field has grown, it has fragmented into specialized areas. This fragmentation makes it challenging for scholars to see the many interconnections relating to uncertainty and to integrate extant work into a common agenda.

We maintain that the various contributions related to uncertainty form a unifying thread woven into the warp and woof of the strategic management field. We hope that by positioning diverse topics within the “four levels of uncertainty” framework of Courtney and colleagues (1997), our analysis can help researchers see how their work connects with other contributions within the big tent of strategic management. Moreover, by sketching out intertemporal dynamics that shift firms and industries leftward or rightward across the boxes, we aim to help scholars understand the connections.

Beyond such unification, strategic management of uncertainty provides a thread to promote the *identity* of the strategy field and express it to outsiders. Throughout its history, strategic management has adapted frameworks from other academic fields to make them useful for top management in business firms. For example, Michael Porter developed his Five Forces framework by adapting the structure-conduct-performance model of industrial organization economics. Regarding tools for managing uncertainty, most of the frameworks documented in Table 3 outside Levels 1 and 4 were *not* invented by strategic management scholars (e.g., decision trees, options theory, Bayesian updating, Monte Carlo simulation, scenario planning, system dynamics, lean startup). Nevertheless, the strategy field has applied them in unique ways—and in some cases has advanced the framework much further than the field where they originated. While other faculty within business schools teach some of the tools in Table 3, none can claim to provide students with a broad perspective on the strategic management of uncertainty.

Thus, we submit that our framework provides a vehicle for teaching managers and students about various strategy tools available to address uncertainty and the contexts in which specific tools are appropriate. This vehicle is needed because the fragmentation seen in research is reproduced in the curriculum. Core strategy courses largely inhabit Levels 1 and 2, teaching analysis, positioning, and planning under conditions assumed to be knowable; entrepreneurship courses inhabit Levels 3 and 4, teaching experimentation, lean methods, and effectual logics; and decision sciences and finance teach powerful individual instruments, from decision trees and simulation to real options, typically detached from the strategic question of when each applies. Students thus graduate with tools scattered across courses and no principle for choosing among them, suggesting that the metacognitive gap observed among practitioners begins in the classroom.

Higher stakes arise when we recognize that uncertainty is not only a condition to which strategy responds but also a variable that strategy chooses: a curriculum confined to Levels 1 and 2 not only leaves gaps in students' toolkits, but also teaches future managers to select the arenas where those tools apply, and to avoid the deeper uncertainty where opportunities are created.

Our framework offers remedies at three scales. Within the core course, our categorization of tools by level of uncertainty (in Table 3) can serve as a capstone exhibit: mapping the tools students have encountered onto the levels shows them what they have learned, what they have not, and which electives fill the gaps. In advanced courses, the dynamics of Section 5 supply the material: a case such as Uber (see Section 2) lets a class practice not a tool but rather the diagnosis that precedes tool choice, and its revision as conditions change. In our teaching experience, Table 3 provides the scaffolding that novices want, while the transitions in Section 5 provide the nuance that experienced participants ask for. Most ambitiously, we can teach an entire course on the strategic management of uncertainty by drawing on the elements of Table 3. Such a course can be

organized to focus on a range of topics along the continuum, from diagnosing levels to matching tools to managing transitions and portfolios. Our claim is accordingly not that strategy is the only field that teaches decision-making under uncertainty; it is that strategy is the natural home for its integration, because strategy is where the choice among the tools is actually made.

Some might differ with our classifications (see the notes to Tables 2 and 3); what is incontrovertible is the outpouring of research on issues arising at all four levels of uncertainty, and the relative scarcity of work on the dynamics that shift firms across them. We hope researchers in strategic management find unity in our framework and can build on the analytical foundation we have provided.

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Appendix A. Prior Integrative Approaches to Strategic Management Under Uncertainty

Author(s)	Title	Summary
Miller (1992)	<i>"A Framework for Integrated Risk Management in International Business"</i>	The author provides a framework for categorizing the uncertainties firms face and outlines strategic corporate risk-management responses.
Courtney, Kirkland, and Viguerie (1997)	<i>"Strategy Under Uncertainty"</i>	To avoid binary views of uncertainty, this article provides a framework for determining the level of uncertainty surrounding strategic decisions and for tailoring strategy to that uncertainty.
Wiltbank, Dew, Read, and Sarasvathy (2006)	<i>"What to Do Next? The Case for Non-Predictive Strategy"</i>	This paper provides a framework for prediction and control, and positions representative literature on strategy approaches within it.
Reeves, Haanaes, and Sinha (2015)	<i>"Your Strategy Needs a Strategy: How to Choose and Execute the Right Approach"</i>	Depending on the environment's predictability and malleability, the authors suggest different strategy approaches. They position specific strategy tools to each approach.
Packard, Clark, and Klein (2017)	<i>"Uncertainty Types and Transitions in the Entrepreneurial Process"</i>	The authors compare different uncertainty typologies and propose a framework that identifies four distinct domains of uncertainty, depending on the nature of the perceived sets of options and outcomes.
Townsend, Hunt, McMullen, and Sarasvathy (2018)	<i>"Uncertainty, Knowledge Problems, and Entrepreneurial Action"</i>	The authors review the multiple research streams that together constitute the literature on knowledge problems to identify critical boundary conditions of uncertainty as an analytical construct.
Magnani and Zucchella (2018)	<i>"Uncertainty in Entrepreneurship and Management Studies: A Systematic Literature Review"</i>	The authors provide a systematic review of the literature about uncertainty in management and entrepreneurship.
Sund, Galavan, and Huff (2022)	<i>"Uncertainty in Strategy Research"</i>	The authors provide an overview of classical work on uncertainty in strategy research and examples of its more recent evolution.
Arend (2024a)	<i>"Uncertainty in Strategic Decision Making: Analysis, Categorization, Causation, and Resolution"</i>	This book provides an overview of uncertainty's ubiquity and impact, connects it to relevant human activities, and builds toward a better understanding of decision-making under its influence.
Dorobat, McCaffrey, Foss, and Klein (2026)	<i>"Knightian Uncertainty in Entrepreneurship Research: Retrospect and Prospect"</i>	This review shows how much knowledge about Knightian uncertainty is accumulating across the entrepreneurship, management, and social science literatures.