

Peer production and uncertainty

Abstract

I argue that peer production is an emerging strategy that firms leverage to reduce different types of uncertainty that impede their strategic decision making. It is distinct from traditional strategies for uncertainty reduction in that it combines several different strategies, leveraging their strengths and minimizing their weaknesses, while addressing the same underlying uncertainty issues that firms face in turbulent and high-velocity markets. The implications for this conceptualization of strategy is that firms do not have to engage in high-stakes bets or hedging practices in order to reduce uncertainty, nor do they have to rely on aggregation of tactics or luck for success. Instead, they can select peer production projects that best address the types of uncertainty that they are facing, effectively extending the firm's boundaries without the costs associated with traditional boundary expansion.

Keywords:

Uncertainty reduction; peer production; open source; firm boundaries

Introduction

Bounded rationality limits strategic choices (Simon, 1991). The primary reason for the limitation is the impairment the decision maker suffers due to uncertainty of what lies outside his cognitive frame (Gavetti & Levinthal, 2000). This uncertainty is equivalent to a lack of information about all of the factors that impact strategic choices and the interconnections between these factors. The literature on strategy making has carefully considered how strategic managers make decisions in the face of uncertainty. They use tactics such as simplification (Schwenk, 1984), satisficing (March & Simon, 1958), trial and error (Alchian, 1950), framing contests (Kaplan, 2008), or imitation (Henisz & Delios, 2001) to cope with cognitive limitations (Simon, 1991).

Another way of looking at the impact of uncertainty is to consider the content of enacted strategies of firms. In turbulent, rapidly changing environments (Bourgeois & Eisenhardt, 1988), uncertainty is a serious constraint on strategy as planning (Mintzberg, Ahlstrand, & Lampel, 2008). Firms must implement strategies that include a variety of tactics such as sensing (Haeckel, 2004), forming alliances (Kanter, 1994), mergers and acquisitions (Walsh & Ellwood, 1991), shaping the environmental structure (Lecocq & Demil, 2006), while walking a careful line between exploration and exploitation (March, 1991) to find the optimal value peak in their competitive landscapes (Gavetti & Levinthal, 2000). There is considerable overlap between decision making strategies and enacted strategies at the firm level, blurring the lines between the two literature pools. Each firm strategy has advantages and shortcomings and new strategies emerge to address issues pertaining to specific environments, idiosyncrasies of firms, and

limitations of extant strategies. These new strategies often do not cleanly fit into the categories in the extant literature. One such emergent strategy, which is distinct from strategies previously considered in the strategy making literature, is firm participation in peer production.

Peer production is a loosely organized means of cooperative production that is different from markets, hierarchies, and networks. It is distinct from alliances in that participants are unbounded, and the outcome of production is explicitly usable by all participants for whatever purposes might suit them. This shared product becomes a resource for complementary value creation and acquisition (von Hippel & von Krogh, 2003) for firms that participate in the peer production effort. It can take on characteristics of technological platforms upon which different firms build their own value-added component (Economies & Katsamakas, 2006). It can take on the form of a reference standard used to drive collective innovation (Osterloh & Rota, 2007). It can act as a means of changing the locus of value of a competing resource outside the peer production effort, realigning the value to be more readily acquired by the participants in the peer production effort (Chesbrough & Appleyard, 2007). All of these outcomes are strategies that deal with environmental uncertainty. This paper argues that firm participation in peer production can be usefully conceptualized as a deliberate strategy to cope with uncertainty. The next section lists and discusses the different conceptualizations of the types of uncertainty that firms face. The following section examines the strategies that firms use to address uncertainty in their strategic decision making. The penultimate section introduces the peer production participation strategy as a distinct strategy and examines its implications. The last section concludes with a

discussion of the implications for management research and strategic management practice along with suggestions for future research direction.

Types of uncertainty

Uncertainty is a “feature of organizational decision making with which organizations must live” (Cyert & March, 1963). The concept has been broken down in different ways by different researchers. Table 1 summarises the types of uncertainty described in the literature.

<u>Types of uncertainty</u>	<u>Example references</u>
Unpredictability	Heiner, 1983
Complexity	Suh, Key, & Munchus, 2004
Information availability	Simon, 1986
Perception	Heiner, 1983
Technology	Fleming, 2001
Subjectivity	LeRoy & Singell, 1987
Institutional	Henisz & Delios, 2001
Risk	LeRoy & Singell, 1987
State	Milliken, 1987
Effect	Milliken, 1987
Response	Milliken, 1987

Table 1: Types of uncertainty

One way of conceptualizing uncertainty is to divide it into unpredictability of the environment and complexity of the environment (Heiner, 1983; Suh, Key, & Munchus, 2004). Part of the boundary between firm and environment is a notion of understanding of what goes on within the firm that acts as a separation of available information from the chaos outside the boundary in the environment in which the firm operates. Firms exist, in part, because they are able to make sense of and coordinate internal factors because they are a limited subset of all the factors in the environment. Firms face uncertainty when they must interact with the environment beyond the boundaries of the firm, as the

environment is variable; what was before may not be so at a later decision point. For example, firms in a given environment come and go; government regulations are introduced; the availability of capital investments varies. Many of these factors that affect firms are unpredictable. Some can be the result of natural disasters. Others are the result of radical political shifts. There is an element of randomness to the unpredictability that cannot be eliminated from the perspective of the firm. Unpredictability can be largely due to the related concepts of variability (Alchian, 1950), and instability (Schoemaker, 1990) in that, for whatever reason, subsequent mappings of the environment will yield different results, hindering decision making.

Complexity can be represented by the number of factors that a strategic manager has to consider in order to make a given decision. By definition, the environment is vastly broader than any given firm, and simply counting all of the factors that affect a firm's course is a daunting task, let alone understanding them all. Complexity can also be represented by the properties of the factors, such as how readily they can be understood, how many distinct properties there are, and how those properties relate to the decision. For example, a factor that relates to environmental complexity could be the state of innovation in a particular product space. One of the properties of the factor is the limitations for the advancement of the development of the product. Understanding the limitations may require an advanced degree in chemistry, if the product is related to the oil and gas industry, or it may require an understanding of political science, if the product is used in election data mining. Even the most intelligent firms cannot hope to delve deep enough in the complexity of a given environment in order to fully understand it.

Environmental unpredictability and complexity mirror two of the constraints of bounded rationality (Simon, 1986), namely information availability and processing ability. Assuming a critical realist perspective on the environment, unpredictability is due to the amount of information an actor has about the underlying nature of the environment and access to that information. Firms cannot possibly have full information on the underlying nature of the environment, and so the environment changes in ways that cannot be predicted from its perspective. The complexity of the environmental information limits the firm's ability to process it to extract the underlying factors. As firms have limited processing ability, the complexity of the environment further constrains their understanding of the environment, producing another form of uncertainty.

An additional source of uncertainty stems not only from the unpredictability and complexity of the environment, but also from the interaction between the two factors. The interaction effect is distinct from the individual effects and suggests that normative strategies for dealing with uncertainty need to consider the implications of these factors as four distinct states representing the 2 x 2 grid of both complexity and uncertainty as either low or high (Suh, Key, & Munchus, 2004). This interaction effect is effectively a form of uncertainty of its own, especially given that it changes normative implications for decision makers.

Uncertainty can also be looked at across levels of analysis. If the environment is unpredictable and complex, firms have differing abilities at untangling the information availability and processing challenges. This ability has been referred to as a firm's "perceptual ability" (Heiner, 1983). The premise is that even if perfect information is available and processing is possible, firms will always, to a degree, have a skewed

perception of the factors in the environment, effectively introducing a certain amount of error into decision making. Firm perceptual ability moderates the effect of environmental uncertainty on decision making such that it is equivalent to representing its own source of uncertainty as a firm cannot understand the degree to which its perceptual abilities are skewed; otherwise, it would simply correct the errors.

The external environment is not the only source of uncertainty. Firms can experience internal uncertainty in forms such as technology (Fleming, 2001), subjectivity of estimated certainty probabilities by decision makers (LeRoy & Singell, 1987), and its experience dealing with specific contexts (Henisz & Delios, 2001). Technology uncertainty arises when a firm attempts to use new, unfamiliar components as internal production factors. As compared to existing components, new components have uncertain performance, fit for particular uses, and stability under varying conditions. Until firms use them, there is uncertainty in how the components will impact production efforts. Uncertainty also arises when attempting to use new combinations of existing components. The interactions between components in systems can radically affect the functionality of the system. Even when components are well known, changing their use, configuration, or interface with other components can to unpredictable results. In both cases, firms have to try out the new components or new combinations in order to reduce the uncertainty they create, as the usefulness of the outcomes are often not clear until attempted. (Fleming, 2001).

In separating the concepts of risk and uncertainty, Knight (LeRoy & Singell, 1987) argued that uncertainty is the critical factor that leads to profit, and firms that better navigate uncertainty will be more profitable. Risk, he argued, was distinct from

uncertainty in that the probabilities for success or failure in any given context were well defined. Risk is what one takes when betting at a roulette table. Uncertainty, by contrast, is when the odds are unknown, or unknowable. Yet, strategic managers have a subjective view in uncertain situations of what, in their minds, the risk of the decision is. This subjective view is not based on hard odds such as those found at a casino. Rather, it is a factor of internal firm uncertainty that resides within the perception of strategic managers. Bearing uncertainty has costs, and the uncertainty imbedded in the subjective estimation of the probabilities of making a profitable decision dramatically impacts these costs, acting as a distinct, internal form of uncertainty.

Internal uncertainty also arises when trying to estimate the match of a firm's capabilities to a given context. For example, a firm's lack of experience in a given market could lead to success in that market, if it brings radical new ideas that revitalize the market, or could lead to failure in the market, if it is poorly adapted to the idiosyncrasies of the market and cannot meet its needs. This lack of experience is distinct from the properties of the context itself in that it is more about fit than about the actual configuration of factors in the given context (Henisz & Delios, 2001). Figure 1 attempts to untangle the different perspectives on uncertainty and map out the effects between firm and environment based on different types of uncertainty.

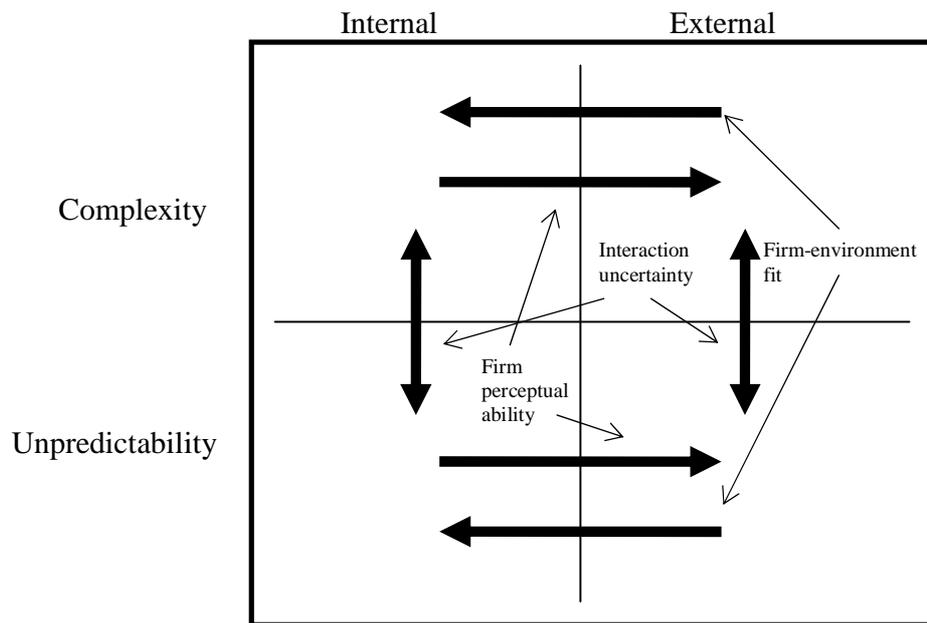


Figure 1: Untangling uncertainty

Milliken (1987) argued that all forms of uncertainty can be mapped onto three distinct forms, state, effect, and response uncertainty. They are based on the notion of the strategic context as a closed system (Thompson, 1967), where strategic decisions are inputs to the system. State uncertainty is the actor's uncertainty about what state the system is currently in at the time a decision is being made. Closed systems have a finite number of states that transition from one to another based on a set of rules. The starting state positions the decision relative to past states and future states. Understanding the current state is crucial to forecasting. Uncertainty due to unpredictability can be mapped onto state uncertainty by conceptualizing unpredictability as an inability of the actor to determine the state of the system. As the actor cannot tell what state the system is in, as it moves from state to state, the system appears to be moving at random from the actor's perspective.

Effect uncertainty is the notion that a firm does not know how a state transition in the system will affect the firm. It represents uncertainty about the impact external environment on the firm, mediated by the interface between the two. Firms that are tightly integrated with their environments may have lower effect uncertainty than firms that operate at arm's length. Unpredictability due to a firm's perceptual ability (Heiner, 1983) can map on effect uncertainty, as a firm's perceptions shape how it understands its interface with the environmental system. Environmental instability (Schoemaker, 1990) can also be considered effect uncertainty, as it can represent a the changing nature of the impact of the environment on the firm over time. Institutional uncertainty, or a uncertainty about a market's "policy making apparatus" (Henisz & Delios, 2001) are forms of effect uncertainty with which firms have to contend.

Response uncertainty encompasses the way the environmental system changes subsequent to a firm action. When a system is disturbed, its natural state progression can change and the rules for transition from one state to another can be rewritten. New states can be introduced and obsolete states cease to exist. Firm action can evoke a response from the environment. This response can come in the form of action by competitors, institutional change, or even customer response. Response uncertainty is the uncertainty related to not knowing what the outcome will be until it is attempted (Fleming, 2001). It also captures complexity uncertainty in that with highly complex systems, it may be difficult to predict the system's response as calculating the output would be computationally infeasible or limited by cognitive models.

Taken collectively, Milliken's typology conceptualizes the firm as interacting with a fixed system. It describes all of the forms of uncertainty in terms of types of

information about the system. The underlying epistemological assumption for is that the firms operate in a system that is knowable. Unpredictability, for example, is assumed to be related to the actors ability to access the underlying information in the system, not a property of the system itself. If we instead assume that systems do not have knowable states, then we reject the closed system assumption and turn to open system uncertainty. Where closed systems allow strategic determinism by the possible states of the system, open systems assume uncertainty, effectively potential unboundedness in terms of states, effects, and response, and focus on adaptation to stimuli from the environment (Thompson, 1967). This approach is one of many strategies for dealing with uncertainty.

Strategies for dealing with uncertainty

Firms will select and execute one or more strategies to cope with uncertainty depending on how they conceptualize the uncertainty and the approaches to dealing with it. Table 2 describes some of the strategies and their advantages and disadvantages.

Strategy	Examples	Pros	Cons	Select References
Accept uncertainty	Constantly evaluate environment; Iterative feedback cycles; Dynamic adaptation	Simplification; Direction	Discontinuities problematic; Scanning costs	<i>Quinn, 1980;</i> <i>Courtney, Kirkland, & Viguerie, 1997</i>
Redefine uncertainty	Enact perspective; Negotiate environment; Manage meaning	Control direction with vision; Focus	Mismatch with reality; Environment can't be directed	<i>Porac, et al., 1989;</i> <i>Pfeffer & Salancik, 2003;</i> <i>Cyert & March, 1963</i>
Disarm uncertainty	Contracts; Routines; Options; Move faster than environment	Measure of predictability; Resilience	Transaction costs; Disruptions	<i>Thompson, 1967;</i> <i>Kogut & Kulatilaka, 2001;</i> <i>Pich et al., 2002;</i> <i>Walker & Weber, 1987</i>
Compart-	Divisional separation;	Actors focus on	Addressing uncertainty	<i>Thompson, 1967;</i>

Strategy	Examples	Pros	Cons	Select References
mentalize uncertainty	Separate operations and research	reducing uncertainty	can lose strategic prominence	<i>Fleming, 2001</i>
Share uncertainty	Pooled interdependence; Alliances; Imitation; Standards	Reduced between-firm effect of uncertainty; Increased information availability	Power relationships; Loss of control over firm direction	<i>Thompson, 1967; Beckman, et al., 2004; Brush, 1996; Courtney, et al., 1997; Farjoun & Levin, 2011</i>
Shape uncertainty	Develop, grow, and direct environment; High-stake bets; Institutional strategy; Corporate political strategy	Control direction of environment; Legitimacy	Potentially large losses; Discontinuous political changes	<i>Courtney, et al., 1997; Lawrence, 1999; Hillman & Hitt, 1999</i>
Ignore uncertainty	Aggregate tactics; Exploit luck; Go with flow of environment;	Low cost; Focuses on metrics of success; Dynamic and flexible	At whim of environment; Can't prepare for all possibilities	<i>Farjoun, 2007; Alchian, 1950; Kogut & Kulatilaka, 2001; Pich, et al., 2002</i>
Simplify uncertainty	Simple/closed modeling; Focus on available information; Restrict choices;	Mental models possible; Choices clearer; Avoid decision paralysis	Not always representative of underlying real system; Masks poor choices; Availability biased over quality	<i>Thompson, 1967; Alchian, 1950; Heiner, 1983; Courtney, et al., 1997</i>
Outwait uncertainty	Make choices when factors become clear;	Less uncertainty when making decisions	Loss of first mover advantage; Uncertainty may not reduce	<i>Courtney, et al., 1997</i>
Describe uncertainty	Script & narrative scenario descriptions; Fractal modeling; Framing contests	Convincing and persuasive; In-depth consideration; Shift reference points	Rhetoric over logic and information; Power dynamics	<i>Schoemaker, 1993; Farjoun & Levin, 2011; Kaplan, 2008</i>
Survive uncertainty	Multiple, varied spinoffs; Diverse selection traits	Hedging bets; Firm continuity	Costly; Continuous structural readjustment; Discontinuities might not come in waves	<i>Pich et al., 2002</i>
Select uncertainty	Established industry practices; Niche industries;	Control of firm-environment link; Cost advantages;	Limits firm type, structure, industry; Difficulty recognizing	<i>Cyert & March, 1963; Pich, et al., 2002; Kogut &</i>

Strategy	Examples	Pros	Cons	Select References
	Shifting markets	Focus	changing environment	<i>Kulatilaka, 1994</i>
Divide & conquer uncertainty	Mix & match strategies; Address common underlying issues; Peer production	Idiosyncratic strategy; Flexibility; Sensing-driven	Complexity; Strategic paralysis; Contextual challenges	<i>Peer production literature</i>

Table 2: Strategies for dealing with uncertainty

One strategy for dealing with uncertainty is to accept that the uncertainty is unavoidable, either because it is unknowable uncertainty, or because there is a mismatch between the firm's ability to reduce or process the uncertainty and its complexity. The firm takes the uncertainty as a given and sets out to deal with it by interacting with its environment in a way that allows constant correction. It constantly evaluates environmental stimuli and uses them as input to iterative feedback cycles for its strategic decisions. The iterative strategy can take the form of incrementalism (Quinn, 1980) where the firm makes small, deliberate, and carefully selected commitments over time. The firm engages in a cycle of sensing, evaluation, and readjusting between each small commitment, attempting to ensure as close a fit as possible between the firm's strategy and the needs of the environment. The iterative strategy can also be broken down in terms of firm functions instead of investment size. Firms may choose to move certain functions to different jurisdictions as the environment shifts instead of attempting to determine the best static placement for a given function. This form of adaptation as conditions change can allow firms to deal dynamically with changes in the environment that are out of their control, such as jurisdictional factors (Kogut & Kulatilaka, 1994). The net result is that firms effectively hedge their bets by making a number of smaller investments across a broader range of investment possibilities. Those that pay off can be iteratively developed, while those that fail can be discarded at low cost (Courtney,

Kirkland, & Viguerie, 1997). The advantages of this strategy are a simplification of the strategic factors from the perspective of the firm which can reduce uncertainty paralysis. However, the increased focus comes at the cost of slower adaptation to large environmental changes that are not detected by the continuous feedback and incremental movement processes. To be effective, the feedback must come from continuous scanning behaviour that can also be costly for a firm.

When uncertainty is not taken as a given, one strategy is to redefine uncertainty as the way a firm conceptualizes itself and its environment. The way a firm views itself and its environment can have a powerful impact on its strategic direction by framing its competition, its market, its strengths and weaknesses, and channelling the effort of intra-firm actors (Porac, Thomas, & Baden-Fuller, 1989). Firms can effectively control the environment and its associated uncertainty by creating a negotiated, enacted environment (Pfeffer & Salancik, 2003) where the firm's strategies are designed in such a way that they become self-fulfilling prophecies (Cyert & March, 1963). The strategic task then becomes the management of meaning instead of dealing with exogenous factors. By directing meaning, the firm can enact the environment that best suits it and focus its efforts in the direction that the shared meaning suggests is optimal (Smircich & Stubbart, 1985). Uncertainty becomes defined as a function of clarity of vision rather than an outside force acting on the firm. This perspective describes a different strategic skill set for firms for dealing with uncertainty where enacting a strategic vision might depend more on CEO charisma (Waldman, Ramirez, House, & Puranam, 2001) than traditionally conceptualized forces such as markets, resources, or costs. The major advantage of this approach is that firms can control their direction with their vision. It allows unity, focus,

and clarify. But it depends on the underlying assumption that reality will allow itself to be constructively shaped. When the firm's approach is a mismatch with reality, or the environment can't be directed, the strategy can be a hard learned lesson at best, or a long-term path to failure at worst.

If uncertainty is conceptualized as necessarily separate from a firm's perspective, another approach is to disarm the uncertainty by imposing certainty on the environment. Contracts can be used to create agreements between actors in the environment that reduce the potential harm that a potential future might have on the focal firm (Cyert & March, 1963). Contracts don't reduce uncertainty in the sense that certain outcomes become more likely. However, they do disarm the uncertainty by helping make sure that regardless of the outcome, the firm is prepared and will not unexpectedly suffer a negative consequence. Firms can also design their internal procedures in such a way that uncertainty is planned around. Routines can normalize the impact of uncertainty by distributing it across areas of the firm, across time, or across accounting measures (Thompson, 1967). The result is a strategy akin to real options in finance (Kogut & Kulatilaka, 2001), where firms make investments in capabilities that permit it to best respond when opportunities emerge. The impact of an uncertain selection on the firm is disarmed to the election of a different option from a portfolio that the firm has at its disposal. Uncertainty in some environments is also effectively disarmed when a firm develops an ability to move much faster than the environment in which is embedded (Pich, Loch, & de Meyer, 2002). A firm can out-pace the uncertainty by making sure that by the time the impact of a particular previously unclear outcome takes place, the firm has already executed its strategy under the previous environmental conditions and moved

on to a new strategy along strategic dimensions no longer related to that particular uncertain factor. Such a strategy is especially viable in slow-moving or niche industries where the rate of environmental change is very different from the firms embedded in them, leading to uncertainty having a limited impact relative to firm decision and execution speed. This strategy allows a measure of predictability for strategic managers. As a result, firms can increase their resilience to the unexpected. But this predictability brings with it increased transaction costs to craft and impose order. Further, it is difficult to disarm uncertainty in the case of large disruptions as disarming it requires a measure of understanding of all the possible outcomes. Accounting for more possible outcomes necessarily requires increased costs, which affects the scope of information availability and, subsequently, decisions (Walker & Weber, 1987).

Firms can deal with uncertainty internally by adjusting the firm structure to compartmentalize the uncertainty such that certain divisions of the firm are created to deal with uncertainty while other divisions focus on exploiting the crucial contingencies that allow a firm to generate and appropriate value (Thompson, 1967). This approach requires internal structural flexibility and accounting procedures that allow for certain parts of the firm to absorb the impact of uncertainty, while others are burdened with keeping the firm afloat. Such arrangements can make compensation and human resource management challenging. As such, only firms of certain size, with established and isolatable crucial contingencies, can deal with uncertainty in this way. The classic example is a separation of research and development for new products as a distinct division of a firm that focuses on reducing technological uncertainty (Fleming, 2001). This approach allows portions of the firm to focus on reducing uncertainty without

distraction from its day to day activities. The assignment of a dedicated internal structural component of the firm can sometimes, over time, lead to a loss of firm-wide strategic awareness of uncertainty issues. When uncertainty isn't forefront in the mind of all firm actors, dealing with it can be less clear to the decision makers who control the resources, who might reduce or eliminate funding for the part of the firm responsible for this critical activity. Every research and development department director has felt these pressures and must make sure to explain the importance of exploration in a manner that ensures that his or her department isn't considered a liability on the financial spreadsheets.

Instead of facing uncertainty alone, firms can share uncertainty to distribute its effects across them, effectively reducing the uncertainty between them, through pooled interdependence. Uncertainty is reduced for all participants because each firm contributes a different perspective from its connection to the environment to a cooperative effort. Firms engage in the cooperation because it creates a commitment between members to exchange capacity to reduce uncertainty (Thompson, 1967). The cooperation can take the form of alliances where firms work together towards some shared goal of mutual benefit that doesn't naturally emerge as a consequence of the concentration of firms in the particular environment (Pfeffer & Salancik, 2003). Firms will seek out different alliance partners depending on the type of uncertainty in the market (Beckman, Haunschild, & Phillips, 2004), the degree of complementarity between them and potential partners (Brush, 1996), and the power relationships they have with other firms (Courtney, Kirkland, & Viguerie, 1997). The sharing of uncertainty can also be involuntary from the perspective of some firms in the case of competitive imitation

(Farjoun & Levin, 2011). Imitation can be conceptualized as a form of cooperative reduction of uncertainty where one firm is setting the strategy and another firm is binding itself to the fate of the decision of the first, leading to a both-win or both-lose scenario. The uncertainty is shared in that the outcome is shared much in the same way as if both firms had agreed to take the same course, as is the case when firms engage in standards development. Pooled dependence built around standardization may be “the least costly [strategy for dealing with uncertainty] in terms of communication and decision effort” (Thompson, 1967), and it enables a larger number of firms to engage in the cooperation relative to a dyadic alliance, reducing a larger portion of the environmental uncertainty, rather than only reciprocal uncertainty between alliance partners. However, individual firms must deal with power relationships that might affect their ability to extract value from the uncertainty reduction. The different players in a pooled interdependence arrangements rarely share equal power, and the more powerful members can influence the course of less powerful firms that lose total control over their own direction (Pfeffer & Salancik, 2003). Firms must be aware of power issues and only enter into pooled interdependence arrangements that are structured such that they will not be subsumed by another a more powerful firm.

Certain firms have a relationship with their environment that does not relegate them to passive subjects of uncertainty. Such firms can implement a strategy to shape uncertainty by participating in the development, growth, and direction of the environment. For example, multi-national firms entering third world economies may be able to directly shape the institutions in those markets, proactively forging an environment that has less uncertainty for the firm. Such a strategy involves making high-

stake bets in the form of large capital investments to set the stage of an industry and ensure a place of prominence for the firm. As such, only firms that have a tolerance for large losses can use this strategy (Courtney, Kirkland, & Viguerie, 1997). In developed economies, firms shape uncertainty by engaging in institutional strategy (Lawrence, 1999) to reproduce or transform the structure of the environment in a way that puts the factors that would otherwise be uncertain within reach. Firms may seek to directly effect government public policy decisions with a corporate political strategy (Hillman & Hitt, 1999) to shape the environment in their favour, reducing uncertainty. This approach gives firms some control over the direction of the environment. The control can be used to develop legitimacy in the institution, which can be valuable for firms on the long run. But firms don't always succeed at shaping their environment. Failed attempts can lead to potentially large losses. Further, discontinuous political changes in the environment can quickly undo the uncertainty reduction of previous large investments, as is sometimes the case when firms are nationalized, or made impractical by legislative changes.

Some authors have suggested that strategies for dealing with uncertainty might be difficult to implement in highly turbulent markets. Instead, aggregation of tactics and luck dominate the strategic landscape (Farjoun, 2007). Further, dealing with uncertainty may not always be paramount because "success is based on the results [of strategic choices], not [their] motivation" (Alchian, 1950). As such, a viable strategy may simply be to ignore uncertainty. Firms can develop a knack for doing the right things without using a deliberate strategy. The key is to exploit luck when it arises. Firms can invest in the development of capabilities that allow them to exploit opportunities without seeking out the opportunities proper (Kogut & Kulatilaka, 2001). In a way, firms unstrategize

their approach to uncertainty by going with the flow of the environment (Pich, Loch, & de Meyer, 2002). This approach can be less costly than other approaches and allows firms to focus on the key metrics of success in its operations. Further, the strategy is dynamic, flexible and adaptable. This strategy is distinct from accepting uncertainty in that it is passive. The firm is at the whim of the environment and necessarily can't prepare for all possibilities. It looks inward to prepare for uncertainty rather than looking outward to the environment to get constant feedback.

Yet firms don't have to completely ignore uncertainty. Instead, they can choose to just simplify its complexity by modeling the strategic environment as a closed system (Thompson, 1967), with a limited set of key factors. Firms can make those factors in the system as deterministic as possible and exclude factors that are not expected to relate to success. Such factors should not be chosen at random, even if luck might play a role. Firms can allocate effort in potentially useful directions with the information that they have (Alchian, 1950). This simplified uncertainty model can be useful for restricting strategic choices that might be more unpredictable than the expected payoff of taking the action (Heiner, 1983). Uncertainty is not binary. Strategic managers usually have some useful knowledge that they can use to restrict their range of choices (Courtney, Kirkland, & Viguerie, 1997). This approach makes mental modelling possible and potential choices clearer. It avoids decision paralysis that can emerge when attempting to solve an overly complex system (Lenz & Lyles, 1985). Yet, the reduced models almost always are not representative of the underlying real system. The result is that the simplification can mask poor choices because the availability of information is biased over the quality of the information used in decision making. Firms must be sure that they have a

sufficient understanding of the underlying system so that they don't miss any major factors in their strategic deliberations.

Firms can sometimes adopt a strategy of outwaiting uncertainty. They can avoid making strategic choices until uncertain factors become clear (Courtney, Kirkland, & Viguerie, 1997). The obvious advantage is that the quality and breadth of information available to make a strategic decision will be higher, presumably leading to better outcomes for the firm. But the strategy may come at the cost of first mover advantage in exploiting new and emerging opportunities. Further, uncertainty might never lower, or may increase over time as firms attempt to outwait it, leaving them in a worst situation than had they made an earlier strategic choice. Yet, if and when uncertainty does reduce, finding and exploiting the opportunities may be less expensive for firms in terms of exploration costs or failed strategic excursions if they avoid making choices during temporary uncertainty. This strategy can only be successfully executed in environments that have some degree of stability to them. If the nature of the environment is that it is constantly unstable, firms will be paralyzed, waiting for clarity that will never come.

Understanding the uncertainty that firms face is key to determining the best strategy to deal with it. Firms can use a strategy of describing the uncertainty by developing multiple scenarios that decompose the complexity of the environment and unknowns in the future. The goal is to make the scenarios as realistic as possible in order to try to determine which one is the most plausible. Firms might use a script or narrative approach in order to work through the different potential futures and select the most likely one (Schoemaker, 1993). This approach can reduce uncertainty that stems from firm perceptions of the environment and environmental complexity. Another way of

describing uncertainty can be to look for the overarching trend rather than small bouts of uncertainty. It may be difficult to untangle luck from resolvable uncertainty when considering strategy choices. Fractal modeling might provide a different representation of uncertainty that better captures the shape of uncertainty on the strategic landscape than traditional models (Farjoun & Levin, 2011). Following these broader trends can allow the firm to implement a strategy that extends beyond the boundaries of what it normally would see as uncertainty. The decision of which scenario is most realistic or which broader trend represents the likely direction of the environment is rarely made by individuals in firms. Instead, individuals create frames surrounding their interpretation of the information that they have at hand and the scenarios that they have devised. They engage in framing contests with others in the firm, sometimes competing for resources for their group over another group and sometimes seeking to advance the interests of the firm as a whole (Kaplan, 2008). Success or failure in the practice of framing, convincing others within the firm that one vision is more likely than another, determines the path that a firm will take, regardless of the actual probabilities of a given outcome or the accuracy of the information used to make the decision. This approach is distinct from enactment as the management of meaning comes from individuals in the mid-level of the firm, and is contested and debated within the firm, not imposed. It may allow actors in firms to be more convincing and persuasive, increasing the intra-firm momentum behind a particular choice. It also allows for in-depth consideration of a limited number of potential outcomes, particularly from alternative reference points. Possibilities and constraints that were not obvious at first consideration may become clearer with closer examination. The risk is that rhetoric may sway a firm in the wrong direction, with impassioned exposition

taking the forefront over sound logic. Power dynamics can affect outcomes, potentially leading to the most powerful actors, not the most accurate visionaries, effecting the strategic direction of the firm.

If firms cannot address uncertainty proactively, they can use a strategy of surviving uncertainty. This approach accepts that environmental uncertainty will lead to an evolution-like selection of firms that have particular properties that might not be knowable to the firm. Firms can create multiple, varied spinoffs that have different properties, aligned along the range of the uncertain possibilities. Uncertain discontinuous events in the environment will progressively eliminate certain variations while the firm survives with the variations that are a fit for the new environment, and creates new variations in anticipation of the next discontinuous event (Pich, Loch, & de Meyer, 2002). This strategy is distinct from an options strategy in that the spinoffs can also generate and appropriate value for the parent firm before the discontinuous event. Effectively, the execution of the option is in the hands of the uncertain environment rather than the strategic decision maker, and the environment effectively decides when an option is “exercised” by eliminating the other options. The underlying assumption is that discontinuous change happens in waves and that firms can prepare and recover in between waves. If discontinuities happen too frequently, firms may have insufficient time to generate spinoff with varying traits and may be selected out in the next wave. Even if there is pacing between the waves, the process of continuous structural readjustment can be costly for a firm, especially if many of the spinoffs don't end up creating and acquiring value for the firm.

Firms can select uncertainty indirectly even when they can't control the environment or the uncertainty it imposes by selecting the environment in which they choose to operate. Different industries have different characteristics and different degrees of uncertainty. Firms can select environments that have lower uncertainty, such as those with established standard practices (Cyert & March, 1963). Niche industries can be less uncertain for firms that focus on value creation along the lines of the niche market needs. If markets change, firms can also select uncertainty by exiting the markets when uncertainty arises (Pich, Loch, & de Meyer, 2002). Uncertainty shifts can be selected against by moving across markets to areas where uncertainty is lower and the firm can compete (Kogut & Kulatilaka, 1994). This strategy is distinct from accepting uncertainty in that the range of strategic options crosses industries rather than within single industries. The scope of the choices is based on a macro level assessment of idealized industries rather than the feedback received from interaction between a firm and the industry in which it is embedded. The advantage of this approach is that firms can control their link to their environment and can leverage it for cost advantages and consistent focus. But, as a result, the type of such firms is necessarily limited and must have a structure that matches with a particular industry. It can be also difficult to recognize changes in an environment when a firm is isolated. The degree a firm is insulated may be inconsistent or incorrectly assessed. Further, niche industries can be susceptible to obsolescence, taking their firms down with them. Firms must be careful when selecting uncertainty to ensure that the selection is actually as stable as it appears to be, and periodically verifying its assumptions.

Finally, firms can divide and conquer uncertainty by mixing and matching strategies as appropriate, internally, externally, depending on the context and environment. The aggregation of different strategies can form a strategy of its own. Such a strategy balances the strengths and weaknesses of different strategies by selecting those best suited for addressing different types of uncertainty and different uncertainty situations. This strategy introduces an additional abstraction of analysis for uncertainty strategies. The second order consideration necessarily introduces additional complexity to the analysis, but allows for a balance of firm and environment idiosyncrasies, flexibility, and sensing that can be used to address contextual challenges. Firms must make sure that the combination of strategies isn't simply an aggregation of tactics and luck (Farjoun, 2007). Instead, an aggregation strategy must address the same underlying issues related to uncertainty and do so in a more efficient way than any of the distinct approaches alone. Peer production is such a mixed strategy.

Peer production strategy

Firm participation in peer production is a mixed strategy for addressing different types and contexts of uncertainty. It aggregates the benefits of the base strategies of accepting, disarming, sharing, compartmentalizing, surviving, and selecting uncertainty.

Peer production and accepting uncertainty. One of the main advantages of this strategy is that it ensures that firms aren't overwhelmed by the complexity or degree of uncertainty. Peer production leverages iterative feedback cycles to allow firms to focus their growth and production on the areas that are most useful for them without making large bets. Peer production can be built into the production activities of firms as an

extension to existing strategies instead of a replacement. It brings with it benefits of environment scanning, through interaction with other participants, without the usual higher costs of environment scanning. The peer production environment is a feedback system of its own that can channel information to a firm that might have been costly for it to obtain otherwise from the external environment. Discontinuous change is also less problematic because peer production projects can typically be more readily repurposed and redirected through forks and aggregation of projects such that the efforts invested are not wasted relative to fit with a new environmental situation after a discontinuous event (Bonaccorsi & Rossi, 2003). It acts as a web of strategic options for the firm, where the web can sense environmental vibrations long before the impact reaches the firm that resides at a more central place in the web.

Peer production and disarming uncertainty. Peer production effectively acts as an options strategy, disarming uncertainty by allowing firms to develop a core competence without the limitations that come from modeling specific cognitive representations. Instead, firms use peer production as a heuristic options strategy that allows fast response to changing situations and that mitigates errors in misapplication of strategy and inertia (Kogut & Kulatilaka, 2001). The selection of a peer production project is equivalent to the "heuristics of investing in exploratory search" (Kogut & Kulatilaka, 2001) where the value of such investments is determined at a later date, often when paired with a complementary asset (von Hippel & von Krogh, 2003). Because the complementary pairing is not known to the firm at the time it enters a peer production arrangement, the particular technological combinations that will yield the most value (Fleming, 2001) are not visible in the current cognitive representation of the firm (Gavetti

& Levinthal, 2000). Firms benefit from the base disarming strategy in that they get a measure of predictability that is embedded in the progress of the peer production effort's governance mechanism and contractual arrangements. They also improve their resilience to uncertainty as they learn from other participants. They create a portfolio of options that can be exercised at a later time, and while they wait for the complementary asset to become clear, they focus on developing their capabilities for adaptation, which yields base benefits as well. The base strategy downside of high transaction costs is mitigated in a peer production arrangement because most of the transactions are already standardized and do not require between-party arrangements. Firms "buy in" to the governance model through participation and do not need to spend money developing thorough contractual agreements from scratch. Even when firms start their own peer performance projects, they can select from an array of previous governance arrangements and pick one that is tailored to their needs and objectives, having the benefit of history to tell which arrangements were the most successful in which contexts (O'Mahony & Ferraro, 2007). Further, when firms face disruptions, they may become aware of the disruption sooner through the peer production network than were they engaging in sensing independently. Peer production projects often shift direction in response to shifts in market need and often have modularity by design to improve their resilience (Bonaccorsi & Rossi, 2003).

Peer production and sharing uncertainty. Peer production can also be usefully conceptualized as a pooled interdependence arrangement. Most peer production projects are loosely organized alliances, where the terms of the alliance are determined by the governance mechanism. The project itself acts as a standardized platform around which

participants base their strategy and build complementary features and products for their idiosyncratic needs (von Krogh & von Hippel, 2006). The platform acts as a shared uncertainty in that the fate of all the firms who choose to leverage the platform in their production activities will be affected by environmental changes that affect the platform. In a sense, firms are engaging in imitation by choosing a shared building block for their individual activities. The result is that there is reduced uncertainty between the firms that are participating in the peer production arrangement. One of the principles of peer production is openness (Benkler, 2002), so it stands to reason that firms that participate will be sharing information with each other to improve their collective knowledge relative to the external environment with each firm benefiting from increased information availability. The governance system of the peer production effectively mitigates the power relationship downside of the standalone sharing uncertainty strategy as it ensures equal standing of participants relative to the platform. Power dynamics can be responsible for shifts in some projects, but firms can always take the existing platform at the time of the shift and continue working on it along a dimension that suits them if they don't want to follow the concentration of power in the projects. Such project forks are relatively uncommon, however, and unlike the case in failed alliances or aborted standards, rarely leads to firms being put in an untenable position. Further, because the locus of value for a firm is related to complementary assets, not the peer production platform itself, any issues surrounding the platform are unlikely to cause a firm to lose control over its direction. Firms get the benefits of sharing uncertainty and pooling effort without the typically resulting power and control downsides.

Peer production and compartmentalizing uncertainty. Firms effectively compartmentalize uncertainty through participation in peer production by separating the part of their firm that will focus on complementary value creation and the part that will focus on advancing the collective project. Usually, there is divisional situation, with research and development focusing on the broader platform, and product design teams focusing on the complementary extensions. In this manner, product development teams operate in a reduced uncertainty environment as they can depend on the platform from the peer production effort. Research and development efforts that focused on uncertainty reduction in the traditional model would run the risk of losing strategic prominence. However, participation in peer production arrangements can be strategically valuable to firms in other ways such as brand development (Pitt et al., 2006) and learning (Grand, et al., 2004). As such, it is less likely that the activity will fall out of strategic prominence and be relegated to reduced resource allocation until it is no longer viable. Further, firms can engaged in mixed participation in multiple peer production projects that collectively reduce uncertainty by triangulating different factors that the firm needs for value creation and appropriation.

Peer production and surviving uncertainty. The peer production strategy also utilizes the survival strategy as peer production projects can be viewed as multiple, varied spinoffs in terms of environmental selection traits. By participating in multiple projects, firms are effectively hedging their bets relative to the broader environmental uncertainty. As firms don't have to create the spinoffs themselves, continuous structural readjustment of the firm is not required (in part because of the compartmentalizing strategy's complementarity), and the costs of using the survival strategy are drastically reduced.

Further, little build-up time is required between waves as firms can jump ship between projects quickly with little inertia. As a result, the strategy can viably be used in high-velocity environments, even with frequent discontinuous change, without firms being selected out. Firm continuity also isn't relegated purely to environmental selection as firms always retain a measure of control over their survival through their complementary assets. In short, peer production increases firm resilience in the face of selection forces without the need for substantial investments into variation.

Peer production and selecting uncertainty. Finally, firms can select uncertainty through peer production by choosing to participate in the peer production efforts that best inform the type of uncertainty they are facing. Much as firms can control the firm-environment link when using the base selection strategy, firms can control their link to the uncertainty reduction approach by selecting the best match of peer production ecosystem for their uncertainty situation. For example, if the environmental uncertainty focuses on the means of addressing a particular user need, firms can join peer production projects that are designing platforms that provide a framework for a solution that can be a stepping stone for multiple, diverse specific approaches for addressing particular user needs. The result is that firms don't have to design full solutions each time they test out a particular way of addressing a user need. Instead, they reduce technological uncertainty by selecting a project that creates a particular type of certainty for a part of the production process. Peer production projects can also be selected for cost advantage or focus reasons. Firms can select projects that are designing or have already solved parts of the value proposition that would be costly for the firm to produce on its own. In this manner, firms reduce uncertainty related to their cost position. If firms use a more enacted

strategy, focus on a particular direction can help the firm reduce its uncertainty as it enacts that future. Selecting particular peer production projects can focus firm effort in the direction that will serve their vision best. The result is a change in perception and subjectivity based uncertainty for the firm. The traditional limitations from the base selection strategy are mitigated as firms do not have to change their type, structure, or industry to participate in peer production projects. Firms of all types, structures and industries participate in the major projects and each one benefits in different ways. This cross-pollination of types, structures, and industries also reduces the difficulties in recognizing changing environments that arise in the base strategy. By participating with different firms in a peer production environment, firms reduce their information uncertainty and have access to cues about the environment changing earlier and with more clarity than they would if they were to scan their local industry and competitive landscape alone. They also can develop relationships with firms in other industries to develop knowledge about those industries that they can leverage in their own industry. The key is to select the project that has the best mix of the particular type of uncertainty reduction that the focal firm needs.

Discussion

This paper began by untangling uncertainty and classifying it into different, overlapping types. Firms that understand differing types of uncertainty will be better prepared and will improve the outcome of their strategic choices. The different strategies that firms can use to cope with uncertainty were then enumerated and their strengths and weaknesses discussed. This exposition provides firms with a full range of approaches

from which to compose their strategy and highlights the circumstances where certain approaches are likely to be more successful than others. The combined result is a contribution to the practitioner literature on coping with uncertainty.

This paper also contributes to the academic literature on uncertainty and strategic choice by providing typologies of uncertainty and firm-level strategies for dealing with uncertainty. The typology ties together disparate streams of literature into underlying principles that could be considered in more depth to advance the research agendas of each stream. The typology also serves to standardize some of the vocabulary used in the extant literature on uncertainty by focusing on the core concerns of firms and a higher level view of potential strategic approaches.

Finally, this paper contributed to both the practitioner and academic literatures by introducing the concept of peer production as a emerging firm-level strategy for coping with uncertainty. Peer production is a combination of strategic approaches for dealing with uncertainty that maximizes benefits of each strategy relative to firm outcomes while minimizing the downsides of each strategy used individually. I argue that peer production should be considered a distinct strategy and should receive increased attention in both management research and practice. It would be fruitful to explore the contexts in which a peer production strategy is more or less successful for a firm, including firm- and industry-level factors. Empirical research could evaluate peer production strategy success by examining returns that firms see on resource allocations into peer production efforts as opposed to other, more traditional resource allocation.

In closing, a key takeaway from this paper is that a peer production strategy challenges the notion that in turbulent, high-velocity markets, strategy becomes difficult and the aggregation of tactics and luck dominate (Farjoun, 2007). Peer production has emerged as a way of keeping a strategy-level focus by using different modeling approaches and combining strategies in a way that provides the best balance of uncertainty reduction for a given firm, while minimizing the costs that each strategy, used on its own, would entail. Strategy is not at an end; rather, it has changed forms as market turbulence and velocity have become the norm. It is the nature of the firm to place its boundaries around crucial contingencies for its production (Thompson, 1967), and it is clear that with the right conceptual framework, peer production strategy does exactly that. By definition, the outcome of a peer production project itself is not a crucial contingency and firm boundaries remain around the complementary factors necessary to generate and acquire value. The strategy comes in the decision to participate, which is effectively an extension of the firm boundaries around peer production talent--producers who are not employees of the firm and who would be prohibitively costly to all bring within the firm (Goldman & Gabriel, 2005)--without the cost of traditional firm boundary extension. This representation of pluralistic firm boundaries for strategic analysis has been considered previously in the literature (e.g. Pfeffer & Salancik, 2003), but has not been evaluated in the context of turbulent, high-velocity markets. The future of strategy lies in this conceptual direction.

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