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RESPONSE

REAL OPTIONS PRICING AND ORGANIZATIONS: THE CONTINGENT RISKS OF EXTENDED THEORETICAL DOMAINS

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As options models move from financial markets to corporate decision making, it is fitting to question the simple domain extension of option pricing theory by considering behavioral decision-making biases. We suggest, however, that, given the negative evolutionary consequences of ignoring optionlike investments, organizations invent heuristic rules to counter these biases. We propose the idea of a domain translation that shows how the basic insight of option pricing can be preserved through evolving complementary organizational rules.

The contribution of real options theory to organizational theory has been to balance the traditional emphasis on uncertainty avoidance with considerations of organizational capabilities to respond flexibly. The interesting and implicit debate published here in *AMR*, over the appropriate understanding of option pricing methods in organizational science, is a reverberation of a more profound conflict between two competing positive theories of behavioral decision making and decision theoretic formulations. In Herbert Simon's phrasing, this conflict is between procedural and substantive models of decision making. We cut to the chase at the start by noting that this conflict suggests a triangulation that arrives at an insightful understanding of how organizations adaptively evolve rules to redress individual biases.

It is also useful from the outset to remember the distinction between what works *heuristically* best in practice and what works *optimally* in the context of a particular abstraction. We suggest that formal methods of real options pricing have an important stake in the domain of positive theory regarding the *market* valuation of investments under uncertainty. As happens in science, in the attempt to extend these methods to other domains, researchers confront new data and modeling challenges. Several innovations have been made in the theory (e.g., correcting for the "shortfall" in equilibrium prices) that offer patches. Yet there remains the issue that the patches may not be theoretically satisfactory.

It is possible that the more *attractive* positive theory provides a less useful heuristic. One should not prejudge this issue by assuming that a theory drawn from empirical observations (e.g., laboratory experiments) is more heuristically accurate. It is of interest to know how good an empirical model is offered by "substantive" theories of decision making, even for investments for which there are relevant financial markets. Surely, though, the proximity of theory and empirical model is warped, as we depart from financial markets toward organizations and product markets—who has ever seen a futures market for innovations? Questioning the extension of the positive theory of financial contingent claims to the domain of organizational research is, thus, fitting. One proceeds at great risk if the goal is to make normative recommendations based on this extended domain. Logically, it follows that knowledge of assumptions and subtleties is more critical in the periphery than in the core of a theory.

Even in the core, the utility of a theoretical tool is surprisingly sensitive to context. Fischer Black taught a class at MIT that consisted of thirty questions, a few of which were addressed in every class session, which asked, "Does this

work if we change condition X?" We might similarly ask, "Does option pricing of contingent claims work in the context of organizational and behavioral biases?"

We offer below a short sketch of a few (by no means all) of the technical and theoretical challenges of real options pricing to this extended domain. In this sketch we point to some of the work preceding this debate that addresses interesting questions of the extended domain of option pricing to organizational decision making. In contradiction to the idea of "domain extension," we propose a "translation" among the theoretical domains of markets and organizations. A good domain translation understands not only the original language and the targeted language but also their correspondence. The problem of domain extension is that the assumptions that make the theory valid in one domain do not apply to the second domain. There is a translation problem.

Stewart Myers (1984) makes a similar observation in his discussion of the disparities between financial theory and corporate strategy, where he notes that the two domains are typically dealt with by different people in the corporate hierarchies—people who often don't "speak the same language." We suggest that firms and organizations often adaptively discover the appropriate translation among domains. We illustrate such an adaptation by calculating the valuation of an option to kill a project with the assumption of a status quo bias. By simply increasing the frequency of audits, we show that the deleterious effects of this bias are easily offset. We propose that, in practice, firms discover such heuristic rules and are not simply prisoners of the experiments on which a lot of our behavioral theories of decision making depend.

A SHORT HISTORY AND GEOGRAPHY OF DOMAIN EXTENSION

The race to invent an economic valuation of an option echoes elements of the story behind the discovery of the double helix in genetics. The players (Fischer Black, Robert Merton, Paul Samuelson, and Myron Scholes) knew each other, watched each other's results, and basically understood the structure of the solution. There was also a distinctive geographical proximity: Black, Merton, Samuelson, and Scholes were located in the spatially contiguous economic and business departments of MIT, although Scholes soon left. All were working on the same problem: since Bachelier, early in the 1900s, researchers understood that stochastic diffusion models could describe the movement of stock prices, but the technical challenge was to figure out how to solve these differential equations for the derivation of market prices.

In many subsequent attempts to solve these equations, researchers posited utility functions. However, they could not use a decision theoretic solution for pricing options where equilibrium prices had to be calculated to be consistent with market clearing. The appeal of net present value techniques is their reliance on equilibrium pricing that *separates* the preferences of traders and the formation of market prices. The breakthrough by Black and Scholes (1973) and Merton (1973) was, of course, the realization that the trader could reconstruct the option through short selling the security and creating a *riskless* position; hence, utilities dropped from the equation. Once risk was eliminated, the equations could be solved, in fact, by the standard mathematics used for describing the random motion of heat.

This elimination of utilities and market risk, by forming a perfectly hedged position, has always been the Achilles' heel in real options applications. There have been many technical solutions, but they all lack the fundamental beauty of the Black and Scholes' insight. In many cases, utility preferences of managers reemerge in the problem. Or, more critically, as we and others have suggested, the decision theoretic properties of organizations become critical data by which to understand the implementation and pricing of real options. Whereas the labeling of these data, such as *costly switching* or *hysteresis*, is not the conventional parlance of organizational theory, the source of these costs is organizational: the cost of hiring and firing, of cognitive errors, and of complementarities.[1]

Real options theory was born almost simultaneously with the discovery of the modern valu-

[1] We first analyzed the relationship of capabilities, complementarities, and options in a working paper released in 1992 that was published in altered form in 2001 and 2003 (see Kogut & Kulatilaka, 1992, 2001, 2003); our 1994 publication was drawn from a 1988 Reginald H. Jones working paper (see Kogut & Kulatilaka, 1994). Option pricing and technical complementarities form the core of the analysis of modularity proposed by Baldwin and Clark (2000).

ation of stochastic contingent claims. Its evolution and diffusion were driven, at first, by association with MIT. Black and Scholes (1973) noted that the firm could be valued by treating the right of the bondholders to call in the value of the firm. In an article on corporate investments, Stewart Myers (1977) perceptively noted that this insight could be applied more broadly to the valuation of corporate and project investments. McDonald and Siegel (1986) made important technical innovations in the application of option valuation to investments that lacked corresponding financial markets, and these were subsequently generalized by Cox, Ingersoll, and Ross (1985).

One of the earliest applications of real options was to the pricing of oil prospects, by Paddock, Siegel, and Smith (1988). Since then, a growing number of real options on a wide range of applications settings have been studied.[2] Dixit and Pindyck (1994) provide extensive discussions of theoretical developments, but real options research hardly dates from their book's publication.[3]

The broader diffusion of real options theory began with its inclusion in the original textbook of Richard Brealey and Stewart Myers (1983), who explained its application to R&D investments. The traditional valuation by net present value bears a set of assumptions that undervalue investments in innovation. By treating the investment as integral, the project carries the market risk.

There are two errors in this treatment. First, the initial investment could be a pilot or staged; obviously, postponing investments has a major impact on net present values. Second, the trial investment may be uncorrelated with the market, whereas the eventual project may not even be accepted; by treating the trial as identical with the eventual investment, the net present value is again depressed, especially by the vicious consequences of compounding the risk premia. Under these assumptions, investments in innovation would be hard to make. Such corporate financial officers as Judy Lewent of Merck, who attended a Sloan School executive program, have endorsed option pricing as a way to preserve financial evaluations in the critical area of innovation investments (Nichols, 1994).

REAL OPTIONS

What does the theory of option pricing (or contingent claim valuation) offer? Option pricing is part and parcel of a tool bag of techniques to analyze situations in which actors consider irreversible investments under dynamic uncertainty. By dynamic, we mean that the uncertainty endures over a period of time, and initial decisions are subsequently revisited. In this environment, choice is both ex ante and ex post, simultaneously. Actors decide what to do based on the realization of current prices (or events); action is ex post to prices. Actors decide what to do based on the future; action is precipitated on the basis of expectations. This characterization lies at the heart of many dynamic stochastic models (best captured by the "Bellman equation").

This interesting question follows: Can actors form expectations that correctly represent the decision environment they will face at the time of future decision making? The doubt over expectations is an old saw. However, it is very reasonable to ask whether actors will have the information and incentives to make decisions in the manner consistent with the theory. Are not organizations political? Will managers not distort or neglect information? Are not options dependent on the decision heuristics and capabilities of an organization (Kogut & Kulatilaka, 1994, 2001; Loch & Huchzermeier, 2001)?[4]

[2] Some of the earlier and more influential applications include Myers and Majd (1984), Majd and Pindyck (1989), and Kulatilaka (1993). See Amram and Kulatilaka (1999) for a review of the applications literature.

[3] It might be noted that there were geographical spin-offs. Saman Majd was a young professor at The Wharton School in the 1980s and first introduced real options into the corporate strategy class. Andy Abel, in finance, later pioneered studies on irreversibility in macroeconomics. Bernard Dumas wrote early articles on options and international finance. Chris Leach explored option valuation and learning. Arnd Huchzermeier wrote his thesis on real options and manufacturing (and has gone on to lead a broad research effort in Germany). In management, Bill Hamilton wrote an early article on the staging of R&D projects, Dileep Hurry was a Ph.D. student who worked with Edward Bowman (and Bruce Kogut), and Rita McGrath, similarly, was a Ph.D. student in the department. This list, including Ph.D. theses, could be extended.

[4] An interesting example of a cognitive error is analyzed in a paper by Chris Leach (1994), who points out that the usual positive relationship of variance to value can be reversed once learning is introduced; variance increases noise and, hence, makes inference harder.

These objections are not unique to option pricing theory (although the "leveraging"—or risk—of optionlike investments may raise the stakes of error). In the very prescient article on finance and strategy we cited earlier, Stewart Myers (1984) asks if the inference from these types of objections is, therefore, that decision makers should not be instructed in the normative theory of corporate finance. Would you not want to know what the positive theory says about the optimal choice? Or is this the case of Odysseus asking to be tied to the mast so as *not* to hear the sirens of option pricing?

Of course, decisions are made in a minefield of potential bias, some that increase and others that decrease the valuations. Many of the known biases are dramatically relevant to option pricing. To name a fundamental bias, the prospect theory of Kahnemann and Tversky (1979) states that managers are likely to treat risk much differently, depending on whether the situation is a happy one (the project is "in the money") or a sad one (the project is very far "out of the money"). The options literature consists of the analysis of interactions among multiple options, some that raise and others that lower the value of an investment (see, for example, Kulatilaka, 1994). A rigorous treatment of the effects of bias on investments in real options similarly requires a more comprehensive analysis of behavioral interactions.[5]

Despite behavioral biases, it is hard to dismiss McGrath, Ferrier, and Mendelow's observation (2004) that many investments in innovations would be foregone if not for an implicit optionlike calculation. It makes sense to render this thought process more transparent. However, after a catastrophic bubble of investments in high technology that implied, in the aggregate, highly unrealistic valuations, it is important to closely examine this argumentation. The effective use of real options in organizations requires, quite simply, a consideration of the kinds of biases that Adner and Levinthal (2004) explore in their paper. Understanding the heuristic merits of a decision rule establishes the proper domain of its application.

[5] One might also add that real options analysis must include a consideration of contracting hazards as well, such as those explored by Chi (2000).

Our view on the use of option models has been that firms err, but sometimes adaptively learn, in their application of these heuristics. There are organizational "masts" of Odysseus that evolve to address abuse. Organizations consist of complementarities in rules and incentives, an observation that goes back at least as far as contingency theory (Lawrence & Lorsch, 1967). Organizations frequently create inconsistency in rules and expectations, as classically summarized by Steven Kerr in the title "On the Folly of Rewarding A While Hoping for B" (Kerr, 1975). The creation of rules consistent with strategies is, no doubt, a discriminating factor in explaining the differential capabilities of organizations.

In the context of real options, we have noted, for example, that multinational firms continued to use traditional methods of managerial accounting, even after a radical change in environment occurred when exchange rates moved from a fixed to floating regime (Kogut & Kulatilaka, 1994). These firms wanted managers to meet budgets projected under a fixed exchange rate. To realign rule and environment, some firms enacted ex ante projected budgeting contingent on the ex post realization of exchange rates (Lessard & Lorange, 1977). Allowing "planned" results to be made "contingent" on floating exchange rates permitted a dangerous degree of latitude by which to evaluate managers. There was no longer a single mast but many ("You will meet your budget depending on the exchange rate"). The known cases of abuse inside multinational firms constitute major scandals.

Yet it would be odd to appeal to the ultimate mast: "Don't even tell me that contingencies can be evaluated." This might be reasonable in some cases. There is a nice and useful paper by Jacques Cremer (1993), in which he basically says if your coauthor claims to be late on a paper, don't listen; coauthors are infinitely clever at inventing such reasons. Similarly, managers are intelligent at "gaming the system." Real options thinking appears to allow them not only to game the system but to write the rules as they go along. There is no mast.

Consider the proposal inside a firm. Corporate headquarters announces during a meeting with division heads that it will permit the acceptance of negative net present value projects that have a compensating option value. "Who is willing," headquarters asks, "to accept negative

value projects whose success is contingent on a future event, such as an innovation success or a growth in demand?" It is well understood that killing a project is hard to do and that monitoring the option value is also very difficult. The hands of all the division managers rise and voices are in unison: "Let me lose money for the corporation with no consequences."

Clearly, this situation is not viable. It is not surprising that interviews with managers—even in cases where options are claimed to be used—show that real options valuation is rarely used; in fact, firms rarely review investment decisions, and yet they don't like to kill projects (Ittner & Kogut, 1995). In general, managers do not like to revisit past decisions, as March and Shapira (1987) reported back from their interviews. Nevertheless, real options considerations appear to represent a significant component of value, and firms that take them into account in appropriate situations should outperform firms that do not. Should managers be tied to the mast and forbidden to engage in optionlike investments because ex post valuation is so difficult?

There is something amiss in this analysis, and one suspects that the claims of a more behaviorally rich account of decision making, inclusive of biases, are not themselves fully based on empirical observations on how firms make decisions. Simulations help to a certain extent. McDonald (2000) found that the use of seemingly arbitrary investment criteria, such as hurdle rates and profitability indexes, proxy for the use of more sophisticated real options calculation. Firms using seemingly arbitrary "rules of thumb" try to approximate optimal decisions. This simulation echoes empirical findings in the seminal paper by Ned Bowman (1963), later verified by Howard Kunreuther (1969), that consistent though approximate heuristics can outperform badly used optimal rules. These results suggest that biases are rampant, and yet firms adaptively find rules that bridge the behavioral context and the substantive theory.

DOMAIN TRANSLATION

The usefulness of having the positive theory at hand is that variations in rules can be evaluated. In their studies, Bowman, Kunreuther, and McDonald use a positive theory of valuation by which to evaluate actual behavioral performance. Sometimes the required adjustments are not very large, and this explains why firms can manage to grow in contexts where the usual decision rules are bad ones (i.e., reject negative NPV values), but the positive substantive rules (e.g., option valuations) conflict with behavioral and organizational biases. In short, firms are adaptive, and some develop the capability by which to evaluate the option potential in investments without losing control.

What adaptive behaviors can we expect to curb the clear bias that managers have a status quo bias and do not like to kill failing projects? The extension of options theory to this organizational domain appears unsuited. However, unless one has a particularly negative assessment of organizations, an initial question might be as follows: Given that exploration of uncertainty is attractive, how might firms come to make optionlike investments and yet not lose control? If the empirical observation is that managers tend toward a status quo bias (e.g., "I don't like to kill sunk investments"), how might organizations counter this bias? The equation of managerial and organizational bias is often made too quickly.

In the spirit of this kind of questioning, domain translation can be a useful guide and, in fact, is a very common practice (think of recent organizational theories of organizational ecology, complex adaptive systems, or rational choice). Are there simple alterations that allow for an insightful translation from real options theory to organizational theory (and vice versa)? Do we think organizations, by design or by adaptation, can be capable of such alterations?

There is, in fact, an organizational rule in the application of option pricing that is quite useful yet simple: review performance more frequently. Now this claim may appear as counterintuitive. If the objection to option pricing rules for investment decisions is that managers don't kill projects, how then would this matter?

It matters if the objection is properly constructed. We start with the observation that achieving appropriate rules for evaluation and incentives constitutes a capability that a firm may or may not have. This capability consists of two complements: (1) the application of option pricing and (2) the maintenance of periodic reviews. Let us make the assumption that a project entails an up-front investment of $15 million. Every year during its five-year development period there is an additional R&D expense of $15

TABLE 1
Value of Project Under Annual Review

	Status Quo Bias (κ)							
Volatility (σ)	**0**	**10%**	**25%**	**40%**	**50%**	**75%**	**100%**	**150%**
0	(15.00)	(18.00)	(22.50)	(25.00)	(25.00)	(25.00)	(25.00)	(25.00)
20%	(1.85)	(4.15)	(7.05)	(9.27)	(10.70)	(14.02)	(16.16)	(16.85)
40%	29.57	25.34	19.67	14.77	11.75	4.46	(0.43)	(5.05)
60%	70.17	63.91	55.01	47.12	42.03	31.27	22.01	12.87
80%	118.08	106.64	94.85	83.76	77.39	62.06	47.69	35.68
100%	163.97	149.36	133.51	120.17	111.34	92.71	75.25	58.97
120%	199.95	183.80	165.41	150.69	141.00	117.97	98.52	79.93

Note: $\kappa > 1$ can be thought of as projects incurring cleanup costs.

million. At the end of the fifth year, a further 50 million is needed to launch the project. The value of the product is realized only if it is launched. Ignoring discounting, a total of $125 million must be invested before any revenue is received.[6] The value of the product is expected to be $100 million (in present value terms), but it is fraught with uncertainty. If there were no uncertainty, the project would surely have negative net present value and be rejected.

We follow the standard assumption in option pricing to model the evolution of the project value uncertainty as a log-normal process. In this case the uncertainty in the value evolution process is summarized by its volatility, sigma (σ). The value of the project in future years will take on an increasingly wider range of possible values with increasing volatility. We use a binomial approximation to model the possible values where these values and the transition probabilities depend on the volatility.[7]

At the beginning of each year, the firm has an option to commit the R&D investment or to abandon the project based on the revelation of new information about the value of the product. Committing an R&D investment confers the firm a real option to proceed to the next year, and ultimately launch the product. If good news is revealed in subsequent periods, the firm will continue the development program. However, if bad news is revealed, the project can be abandoned, but at a cost. We allow the firm to abandon the project, with no additional cost (other than losing the initial investment), within the first year. Thereafter, it will cost a percentage (κ) of the cumulative R&D investment committed up to that time. This parameter reflects the status quo bias. For instance when $\kappa = 10$ percent, abandoning the project in year three after having invested $45 million will cost the firm $4.5 million.

In our model the values at which the firm's option to exercise decisions (when to proceed, when to abandon) are chosen internally so that total value net of investment is maximized. Table 1 summarizes the impact on the project of varying the uncertainty (σ) and the status quo bias (κ). When there is no uncertainty, the option value is zero and the project, by construction, has a negative net present value. As uncertainty increases, the possible range of values increases and the option becomes more valuable. With status quo bias, however, the firm will behave suboptimally, and the value of the project will be reduced. As we increase the status quo bias, the option value will fall monotonically (as we move to the right along any row). Our inference, however, is simply that such biases can be built into the simulated values that were estimated by a short spreadsheet program.

A more interesting consideration is whether simple organizational rules can be developed to offset the deleterious effects of a status quo bias. The translation of option pricing from financial markets to real investments requires adaptation that pushes the organizational process closer to market assumptions. Option pricing hedges are based on continual trading. The organizational

[6] In order to isolate salient features of this model, we set the interest rate at 0.

[7] According to a binomial model, within a time period t the value can rise at a rate u ($= e^{\sigma\sqrt{t}}$) or fall at a rate $1/u$, with the probabilities of transition that depend on σ and the interest rate.

TABLE 2
Value of Project Under Quarterly Review

	Status Quo Bias (κ)							
Volatility (σ)	0	10%	25%	40%	50%	75%	100%	150%
0	(15.00)	(16.50)	(18.75)	(21.00)	(22.50)	(25.00)	(25.00)	(25.00)
20%	(1.85)	(3.77)	(6.14)	(7.80)	(8.82)	(11.23)	(13.35)	(14.34)
40%	29.57	25.94	21.20	17.07	14.49	8.89	5.19	2.06
60%	70.17	64.78	57.24	50.62	46.49	37.70	29.72	23.70
80%	118.08	108.63	98.07	88.80	83.40	70.61	58.97	49.99
100%	163.97	151.68	137.99	126.37	119.08	103.85	90.12	77.66
120%	199.95	186.58	171.00	157.93	150.04	131.83	117.17	103.23

counterpart is to provide more frequent evaluations of the option value. This activity has a useful side benefit in decreasing the costliness of a status quo bias.

Table 2 presents the results for the same project described above, but now evaluated on a quarterly basis. The project valuation has increased dramatically compared to the earlier case. The initial intuition might suggest that, given a status quo bias—that is, the unwillingness to kill a project—more frequent reviews would compound the error. However, the simulated results suggest the opposite. It is easy to understand why. There are more opportunities for the firm to correct the investment decision and avoid regret.[8]

In other words, the status quo bias can be dynamically decreased by increasing the periodicity of the reviews. Unless one wants to make the unreasonable assumption that the only bias is the status quo and it is always operative, the chances of benefiting from accounting for option values can be improved by adjusting the organizational rules. This is a fairly simple adjustment that illustrates how complementarities lead to coevolution—this time, in investment and financial accounting rules.

Is there evidence that firms in higher-risk environments experience this adjustment? We expect that venture capitalists would surely insist on frequently monitoring their investments that are explicitly treated as option placements; the payoff is expected to be realized through an uncertain stock exit in the lucky event the firm should go public. In studies on venture capital, researchers routinely note that frequent visits to management by investors, in addition to board meetings to ensure governance, are far more common compared to shareholder oversight of public corporations. No doubt, these reviews are useful for deciding not only whether to commit more money (or to kill the investment) but also whether to offer investment advice (see, for example, Gompers & Lerner, 1999, and Lerner, 1995).

There is, in fact, prima facie evidence that projects are killed. Bankruptcy rates, for example, move up and down with business cycles. Pharmaceutical companies report failure rates of 90 to 95 percent of projects, with most of these failing prior to regulatory hurdles (Ittner & Kogut, 1995). Xerox Parc has been noted for its failure to make use of its technology, but a different view is that it has had a rather high rate of success for innovative research and a noted capacity to kill projects; some have claimed that this kill rate has been too high (Chesbrough, 2000). Unfortunately, Xerox Parc has had a harder time writing in the option claim to the intellectual property—not a failure to a kill an option, but to simply recognize it. Parc has adaptively learned over time to write such contracts.

CONCLUSIONS

There is reasonable evidence at this point that organizations are sensitive to option considerations. Car and computer companies build "platforms" at an incremental cost that allow for modularity, which can be well understood as real options (Baldwin & Clark, 2000). Studies on

[8] It is worth noting that for projects that are close to breakeven (NPV = 0), more frequent decisions will not have a similar effect. This is because the options to abandon are rarely exercised, and the frequent decisions have little effect.

investments in high technology and in foreign entry suggest option considerations, as do valuations placed by stock markets on cross-border acquisitions. The evidence is not unanimous across studies, partly because options are everywhere and they collide in their implications. Folta and O'Brien's (2002) recent paper nicely captures the dilemma as "dueling options." And the evidence is perhaps negative because of limitations on managerial decision making. However, negative evidence does conform with the Popperian tenet of a theory's implications being open to falsification.

It is probably too precious to offer the criticism that theoretical domains differ in their theorists' behavioral assumptions. Substantive theories of decision making lack considerations of behavioral bias. There is, and will be, great interest in developing other domains of inquiry. Yet one is always surprised by how substantive assumptions are translated into these domains. Typologies of inertia, such as the relationship between the coarseness of uncertainty and the degree of flexibility, imply that organizations adapt in their capabilities, inclusive of decision rules. It is interesting that a hazard rate is the conditional probability of exercising an option. The stochastic calculus of growth that merits passing consideration in Tuma and Hannan (1984) need not be limited to passive resignation. It makes sense that firms search, in a path-dependent way, for options.

Research is often like the "policy martingales" that intrigued March and Olsen (1984). Charles Kindleberger once observed that, early in his career, he calculated the net present value of learning mathematical modeling and decided rationally not to. It is likely that research trajectories, much like technological trajectories, reveal the same path dependence; the arrow of time is unavoidable. It is important to remember, despite some misleading statements and figures, that real options processes can be path dependent, such as mortgages that can be redeemed and carry an annual interest rate cap. Similarly, complementarities in organizations render options path dependent, as do behavioral biases.

It is wrong to assume implicitly that behavioral biases do not themselves "duel" with each other, as do options, or that competitive politics in the firm will not lead to overkill rather than underkill, or that organizations are unable to develop capabilities to counteract these pathologies. Perhaps the work of a good research community is to offer a similar organizational check on biases in individual commitments and to leave open a broader set of research options. It is likely, as organizational and strategic theorists grapple with overtime dynamics, that concepts from the domain of real options theory will continue to be translated into organizational research.[9] There is no question this translation can be skillfully conducted in both directions.

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[9] Recall that Lippman and Rumelt's (1982) model implies an option valuation, as can be seen in their analysis of the value consequences of a mean-preserving increase in variance. The implied strategy for firms that succeed in this first round is not, however, to gamble but to find options to exploit their "postentry dependence" on their initial lucky draw.

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