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Working Paper
2019/56/EFE

Knowledge Mobilization in the Face of Imitation: Microfoundations of Knowledge Aggregation and Firm-Level Innovation

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Strategic Management Journal, forthcoming
Accepted for Publication: December 2019

Research summary. Firms in technology-based settings must mobilize individual knowledge to continuously execute innovative new opportunities. Because knowledge is generally conceptualized at the firm-level, however, we have only a limited understanding of how individual-level knowledge aggregates to firm-level outcomes. We develop a microfoundational theory to examine the individual-level foundations of firm-level innovation in the context of imitative competition. A key insight is that despite intuitions that knowledge mobilization should protect firms from rival imitation attempts, knowledge mobilization can often benefit rivals more than the focal firm itself, due to a process of continuous knowledge spillover-sharing amongst rivals. In addition, while knowledge-based advantages are often thought to be temporary without some isolating mechanism, sustainable advantage may emerge under limited conditions under which knowledge-mobilizing firms outrace rivals' imitation efforts.

Managerial summary. Managers in fast-moving technology-based industries must mobilize the knowledge of individuals in their firm to execute new market opportunities arising over time. To do so, managers can employ processes such as transfer, collaboration, and recombination, which allow firms to draw on and use individual-level knowledge in different ways. We develop a computational model to generate insight into the implications of these different knowledge mobilization mechanisms in settings where individuals interact not just with others in the focal firm, but also with imitating rivals. We find that knowledge mobilization can often benefit rivals more than the focal firm itself due to a process of knowledge spillover-sharing amongst rivals. In addition, we develop insight into the limited conditions under which knowledge-mobilizing firms can achieve a sustainable advantage.

Keywords: Knowledge mobilization; imitation; innovation; microfoundations

INTRODUCTION

In fast-moving technology-based market settings, a central challenge for firms is to utilize the knowledge held by individuals in the firm to execute innovative market opportunities that arise over time (Brown & Eisenhardt, 1997; Davis, Eisenhardt & Bingham, 2009; Rindova & Kotha, 2001; Shane, 2000). Such settings are characterized by ongoing change, temporary advantage, and hyper-competition, which require firms to match their own knowledge and capabilities to emerging opportunities in domains such as product development and new market entry (D'Aveni, Dagnino & Smith, 2010; Roy, Lampert & Stoyneva, 2018; Wiggins & Ruefli, 2005). As multiple streams of the strategy literature argue, individuals play a central role in this process of firm-level opportunity execution (Coff & Kryscynski, 2011; Dahlander, O'Mahony & Gann, 2016; Grigoriou & Rothaermel, 2014). Yet while the idea that knowledge is ultimately held by individuals may not be particularly contentious, much of the strategy literature nonetheless conceptualizes knowledge as residing at the level of the organization or team (Felin & Hesterly, 2007). Of course, viewing knowledge at this macro level has led the strategy field to important insights, expanding our understanding of a host of firm-level issues linking knowledge and innovation to competitive advantage (e.g., Arora & Gambardella, 2010; Garg & Zhao, 2018; Helfat *et al*., 2007). At the same time, however, it has meant that the aggregation processes that link individual-level knowledge to firm-level innovation outcomes have remained relatively understudied.

This gap in our understanding of how individual-level knowledge aggregates to influence innovation at the level of the firm points us toward potentially fruitful avenues for theory development. This is because alternative approaches to mobilizing the knowledge of individuals inside a firm may have non-obvious effects on the heterogeneity and distribution of a firm's knowledge pool, in turn influencing the extent to which firms can capture opportunities under varying market conditions. In addition, imitation by rivals, enabled by individual-level knowledge flows, is closely intertwined with the innovation process (Almeida & Kogut, 1999; Audretsch & Feldman, 1996; Saxenian, 1994; Singh, 2005). Knowledge mobilization and imitation-based competition thus represent individual-level processes that may jointly interact with one another in unexpected ways when aggregated to the firm-level. A deeper theoretical understanding of this aggregation processes thus promises to substantively increase our understanding of the determinants of heterogeneity in firm-level innovation outcomes.

There have been numerous calls to more deeply examine the role of individuals in influencing macro, firm-level outcomes. Scholars have argued for "opening up the proverbial black box of the firm" by taking individuals as the natural starting point for theory development with regard to the antecedents of firm-level phenomena (Felin & Hesterly, 2007: 213). A microfoundational approach holds the promise of deepening our understanding of the "individual-level and social interactional antecedents" (Felin, Foss & Ployhart, 2015) that lead to heterogeneity in firms' knowledge-based outcomes. Pursuing a microfoundational research program, however, requires attention not simply to individuals as a focal unit of interest per se, but more importantly to the processes that *aggregate* individual-level considerations to the level of the firm. As Barney and Felin (2013: 144-145) put it, this means systematically looking at "the origins and nature of the macro," with aggregation as the "sine qua non of microfoundations."

In developing a microfoundational theory of individual to firm-level knowledge aggregation, we direct our attention toward the most salient forms of individual-level interactions occurring in knowledge-based contexts. We focus in this regard not only on *intra*-firm interactions among individuals, but also on *inter*-firm interactions that we argue play an equally important role in opening the black box of firm-level innovation outcomes. This focus on *both* the intra- and the inter- distinguishes our theory development effort from extant microfoundational work, where the relevant set of interactions is generally confined to within-firm boundaries. We include inter-firm competitive considerations in our theory development because spillovers of knowledge among competing firms are of particular importance in technology-based settings (Ethiraj & Zhu, 2008; Knott, Posen & Wu, 2009; Posen & Martignoni, 2018).

By focusing attention on the conjunction of intra- *and* inter-firm processes, we bridge two distinct streams of work on knowledge and innovation. First, work on the intra-firm processes of knowledge mobilization addresses the ways in which managers can create a productive delta between "what is known [by individuals] within the organization and what is actually put to use" (Szulanski, 1996: 38). This stream of work examines issues such as within-firm social networks (Hansen, 2002; Nerkar & Paruchuri, 2005; Phelps, Heidl & Wadhwa, 2012), divisional recombination (Karim & Kaul, 2015), and knowledge variety (Caner, Cohen & Pil, 2017). Second, work on imitation suggests that imitation-based competition stemming from the spillovers of individual knowledge across firms can erode the firm performance benefits to firms of their innovation efforts (Ethiraj & Zhu, 2008; Posen & Martignoni, 2018; Zander & Kogut, 1995).

Viewed collectively, each of these two streams of research appears to form a productive microfoundation by addressing individual-level interactions that aggregate to macro-level outcomes. Yet the two seem incomplete without one another. While the mobilization stream offers descriptions of the intra-firm mechanisms underpinning innovation, it pays less attention to competitive concerns that could impact mobilization effectiveness. And while the imitation stream offers a theory of the inter-firm effects of knowledge spillovers under conditions of imitation, it pays less attention to how this knowledge is subsequently used by individuals within firms. Both intra- and inter-firm mechanisms are thus implicated in the aggregation process linking individuals to the macro; yet the ways in which this joint interaction plays out is less than clear.

While our microfoundational theory takes into consideration the collective intra- and inter-firm interactions among individuals that may in the aggregate influence firm-level innovation outcomes, what is perhaps most important for strategy scholars is to have a testable and predictive theory linking particular strategic choices around individual-level knowledge mobilization to systematic heterogeneity in firm-level outcomes. To this end, we focus on three distinct knowledge mobilization mechanisms that firms might employ, linking these distinct design considerations to firm-level performance as captured by the firm-level ability to execute opportunities in the face of imitative pressures: (1) the movement of knowledge among individuals in the firm ("transfer"); (2) the degree to which individuals can borrow (i.e., access and use) knowledge from others when they work together ("collaboration"); and (3) the creation of new knowledge from elements of individuals' existing knowledge ("recombination").[1]

We employ a computational model to develop our microfoundational theory. Our model focuses on the link between individual knowledge and firm-level innovation, taking into consideration intra- and inter-firm factors, together with their individual and joint interactions. A computational methodology is appropriate given the state of development of the literature on which we build: there is *some* baseline theory, but it is under-developed, and as such, it can benefit from systematic exploration via simulation modeling (Burton & Obel, 1995; Davis, Eisenhardt & Bingham, 2007). We use stochastic process modeling, which allows us to model a flow of heterogeneous opportunities into an environment containing a focal firm together with a pool of rivals. We conceptualize firms as sets of inter-linked individuals with distinct and widely distributed knowledge whose task it is to capture these opportunities. In a series of simulation experiments we vary firms' use of the three knowledge mobilization mechanisms, as well as the imitation conditions and opportunity space characteristics that firms face.

This study generates several conceptual insights. First, while it may be natural to infer

[1] We define knowledge mobilization as a set of processes, implemented at the firm-level, that enable firms to draw on and use knowledge held by individuals in the firm. As such, knowledge mobilization can be interpreted as a type of capability (Helfat *et al*., 2007), supported by resources and routines, that a firm can employ to allow for the manipulation of individual-level knowledge. As we discuss in the Theoretical Background section, this can entail the movement of, access to, or creation of knowledge.

from the macro-level literature that the effects of knowledge mobilization are fully internalized and will protect the firm from the negative effects of spillovers to imitating rivals, we find that mobilizing knowledge can in many cases amplify the negative effect of spillovers through a process we label "knowledge spillover sharing," where rival firms continually share and propagate the focal firm's knowledge amongst one another. The extent to which this knowledge spillover sharing process causes firms' knowledge mobilization efforts to backfire is shaped by characteristics of the imitative conditions under which the firm operates, such as its susceptibility to imitation and rival population size.

Second, while strategy and innovation scholars, drawing on ideas anchored in the organizational behavior literature, have shown that the movement, borrowing, and creation of knowledge in a firm can engender innovation, these individual-level processes have been implicitly assumed to be equally effective at the firm-level. We show, however, that these three mechanisms contribute differentially to firm-level opportunity execution under varying imitation and opportunity space conditions. Their contingent efficacy stems from differences in how they enable individuals to distribute and accumulate knowledge within a firm over time.

Third, while knowledge mobilization has been shown to allow for relative innovation benefits vis-à-vis rivals, it is generally thought to generate only temporary performance advantages without some exogeneous isolating mechanism (e.g., tacit knowledge or IP protection) that protects knowledge from value-destroying imitation. Indeed, we observe temporary performance advantages in most cases, except under unique conditions of high complexity in the firm's opportunity space, where recombination can sustain the innovation-based competitive advantage held by the focal firm.[2]

[2] We use the terms "performance" and "competitive advantage" as shorthand for a very specific form of knowledge-based firm-level outcome (opportunity execution). Of course, performance and competitive advantage in the broader sense are dependent on numerous other factors outside the scope of our model. Our central concern here is with the aggregation of individual-level

Taken together, these conceptual insights allow us to make two sets of contributions to the strategy literature. Most importantly, we develop a microfoundational theory that addresses the impact of knowledge residing in individuals on firm-level innovation by taking into consideration the interactions and aggregation processes occurring within and across rival firms. We show that alternate approaches to individual-level knowledge mobilization can influence the distribution and heterogeneity of a firm's knowledge pool, and in so doing have implications for firm-level opportunity execution (D'Aveni *et al.*, 2010; Roy *et al.*, 2017; Wiggins & Ruefli, 2005). This advances us toward a deeper theory of knowledge-based advantage (Teece, 2007) that addresses the micro-level "proximate causes of macro phenomena" (Felin *et al*., 2015: 590). Another contribution is to develop insight into the factors that inhibit or facilitate knowledge-based imitation, while holding constant factors such as knowledge tacitness. Whereas knowledge tacitness has constituted the focus of much of the prior literature on knowledge-based competition (Knott, 2003; Reed & DeFillippi, 1990; Spender, 1996) our focus solely on intra- and inter-firm individual-level factors while holding tacitness constant allows us to push beyond the effects of knowledge tacitness in our understanding of knowledge-based outcomes, and to generate insight into the contingent effects that shape knowledge mobilization in the face of imitation (Ethiraj & Zhu, 2008; Knott *et al*., 2009; Posen & Martignoni, 2018).

THEORETICAL BACKGROUND

Knowledge mobilization

The three knowledge mobilization mechanisms we model are anchored in prior literature on the microfoundations of organizational innovation.[3] Although the diversity of this literature precludes

knowledge, and its effects on firm-level opportunity execution. The terms performance and competitive advantage should thus be interpreted through this lens of firm-level opportunity execution, driven by aggregated individual-level knowledge.

[3] This literature spans numerous streams, with our aim being to distill this work into a set of conceptually distinct processes. Although sometimes different in application or detail, for each mechanism we aim to capture a core underlying process that appears to recur in the extant literature, and that might consequently inform knowledge-based performance differences.

a strict mapping from the labels of transfer, collaboration, and recombination to pre-existing constructs, these labels do represent distinct forms of knowledge mobilization with roots in processes scholars have previously studied. Our objective, however, is not to introduce new constructs; rather, we map extant studies onto a set of terms which we use as shorthand to refer to distinctive knowledge mobilization processes. We discuss each mechanism in turn, noting the distinctive intra-organizational processes on which it is based, and highlighting the literature from which it is drawn. This discussion is summarized in Table 1. In the Online Supplementary Material, we provide examples of how each of the three knowledge mobilization mechanisms is employed in practice.

[Insert Table 1 here]

Transfer. The first mechanism, *transfer*, can be characterized as the *movement* of knowledge from one individual to another within an intra-firm network of individuals. This movement of knowledge is not tied to the execution of a specific opportunity. Rather, it proceeds on an ongoing basis as knowledge diffuses among individuals within a network. Prior work has discussed such instances of within-firm knowledge transfer (Gupta & Govindarajan, 2000; Zander & Kogut, 1995). Scholars point to inter-individual networks as a powerful means to mobilize knowledge in a firm (Argote & Ingram, 2000; Beckman & Haunschild, 2002), as well as to the knowledge-related benefits of transfer in contexts such as manufacturing (Tsai, 2001), electronics (Hansen, 1999) and contract R&D (Reagans & McEvily, 2003). While challenges in measuring the effectiveness of transfer arise from variation in knowledge codifiability (Argote & Fahrenkopf, 2016), learning speed (Argote, 1999), network structure (Reagans & McEvily, 2003) and recipient characteristics (Szulanski, 1996; Szulanski & Jensen, 2006), the movement of knowledge among individuals has been seen as a means of boosting a firm’s ability to capture opportunities arising over time (Argote & Ren, 2012).

Collaboration. The second mechanism, *collaboration*, can be characterized as the ability of individuals to *access* the knowledge of other individuals to whom they are connected. Whereas transfer involves the ongoing diffusion of knowledge in an inter-individual network, collaboration involves the ability to draw on and access a wider pool of knowledge—i.e., the knowledge of the others to whom an individual is connected—when faced with a new market opportunity.[4] The effect of collaboration is therefore to increase the search space of an individual with respect to their accessible knowledge when presented with a market opportunity. Collaboration is enabled by investments in technological and organizational processes that facilitate the retrieval and access of information from other employees. Moreover, it has roots in the literature. For example, prior work suggests that individuals may have multiple team memberships that can enhance productivity and learning through access to the knowledge of others (Ancona & Caldwell, 1992; Gibson & Vermeulen, 2003; Hansen, Mors & Lovas, 2005; Mors, 2010; O'Leary, Mortensen & Woolley, 2011). This can occur in the context of cross-business unit collaboration (Martin & Eisenhardt, 2010) as well as in situations where individuals span multiple domains (Choudhury & Haas, 2018), and is enabled by technologies and processes for knowledge sharing within organizations (Haas & Hansen, 2007).

Recombination. The third mechanism, *recombination*, can be characterized as the *creation* of new knowledge from existing knowledge within the firm. As such, it is distinct from transfer and collaboration, both of which mobilize existing knowledge. In contrast with collaboration, which involves searching the knowledge space of colleagues with whom one is connected when attending to a specific opportunity in question (i.e., access), recombination involves creating *new* knowledge by combining the existing knowledge of connected individuals, and applying this

[4] With collaboration, when Individual A executes an opportunity using the knowledge of Individual B, to whom they are connected, Individual A retains that knowledge vector. This form of knowledge accumulation is distinct from transfer in that it is not ongoing and passive, but rather tied to the execution of a particular opportunity. At the same time, at an aggregate level, it also allows collaboration to alter the distribution of knowledge within the firm (because knowledge flows from B to A).

newly-created knowledge to a specific opportunity (i.e., creation).[5] Recombination is central to many accounts of the microfoundations of technological innovation. Prior work, for example, focuses on how innovations emerge from combinations of knowledge across distinct technical domains (Fleming, 2001; Hargadon & Sutton, 1997) and the ways in which intra-organizational knowledge can be generated through structural recombination across business units (Karim & Kaul, 2015). Recombination is the outcome of combining knowledge of different types (Carnabuci & Operti, 2013; Hsu & Lim, 2014; Katila & Ahuja, 2002; Taylor & Greve, 2006), and often occurs via co-production among individuals inside the firm (Baker & Nelson, 2005; Singh & Fleming, 2010; Toh & Polidoro, 2013). More generally, recombination enables the firm to create a more heterogeneous knowledge base to capture more diverse market opportunities.

Imitation conditions

Imitation has long been a core concern of scholars examining knowledge-based competitive advantage (Ethiraj & Zhu, 2008). Posen, Lee and Yi (2013: 149-150) note that "the issue of imitation lies at the heart of the strategy field," and that "classical research embodies implicit assumptions that unprotected knowledge diffuses rapidly." Variation in the nature of imitability shapes the extent to which knowledge is protected from spillovers (Csaszar & Siggelkow, 2010; Henderson & Cockburn, 1996; Owen-Smith & Powell, 2003). This can arise from characteristics at the level of the individuals, the firm itself, or the industry in which the firm operates (Barney, 1991; Lippman & Rumelt, 1982; Reed & DeFillippi, 1990). Knowledge mobilization distributes and creates knowledge heterogeneity within the firm, and as such it can have implications for the degree to which the firm achieves competitive advantage vis-à-vis its rivals. We focus on three distinct imitation conditions that we posit shape the efficacy of knowledge mobilization under

[5] As with collaboration, we model recombination with a form of knowledge accumulation: when Individual A executes an opportunity by combining a knowledge vector with Individual B, both individuals retain the newly created knowledge vector.

imitative competition: *symmetry*, *absorptive capacity threshold,* and rival *population* size.

Symmetry. The dimension of *symmetry* in imitation stems from differences among a focal firm and its rivals with respect to who is susceptible to imitation. Knott *et al.* (2009) point out that there may be a directionality in the degree of spillover of knowledge among firms. This directionality leads to two conceptually distinct cases. On the one hand, the focal firm may be susceptible to imitation by rivals, representing an asymmetric situation in which there is an innovator from whom knowledge flows, and who is then subject to the downsides of spillovers of its knowledge to competing rivals. On the other hand, competition may be more symmetric in the sense that *all* firms can imitate *one another*. As Knott *et al*., (2009: 373) note, firms may "draw equal benefit from the contributions of all other firms." In our conceptualization and associated modeling effort, we capture these ideas in our view of firms operating either in an *asymmetric* environment, where knowledge-based rivalry occurs such that there is a pool of imitators that can copy the focal firm (but not vice versa); or a *symmetric* environment, in which all firms, the focal and its pool of rivals included, can each copy one another.[6]

Absorptive capacity threshold. A second factor shaping imitation is the *absorptive capacity threshold* required for an imitating firm to capture knowledge through a knowledge spillover. Absorptive capacity is a key factor influencing the difficulty of imitation; it reflects the idea that a knowledge spillover recipient must already hold some threshold level of related knowledge in order to successfully copy knowledge from the source (Cohen & Levinthal, 1990). The ability to recognize, capture and subsequently employ knowledge stems from having a sufficient baseline understanding upon which knowledge flows can occur. Variation in the requisite absorptive capacity threshold for imitation suggests that imitative competition can vary

[6] For example, an asymmetric environment may consist of a dominant multinational in an emerging market who is subject to imitation, while a symmetric environment may be a mobile app ecosystem where firms can easily and commonly copy product features from one another.

in its efficacy (Posen *et al*., 2013) as a function of various factors that collectively influence knowledge diffusion across organizational boundaries (Greve, 2009; McEvily & Chakravarty, 2002; Reed & DeFillippi, 1990; Winter, 1987; Zander & Kogut, 1995).

Population. A third factor shaping imitation is *population* size of the firm's rivals. The degree to which rival imitation is of competitive concern is likely to be a function of the degree of intensity of the firm's pool of imitating rivals (Vroom & Gimeno, 2007). Population size constitutes a key consideration in determining the degree to which characteristics of industry structure such as market concentration shape firm profitability (Bresnahan & Reiss, 1991; Demsetz, 1973; Lippman & Rumelt, 1982). In the context of the knowledge-based competition we study, a larger pool of rivals may increase the likelihood that a particular rival can ultimately outrace the focal firm in addressing new market opportunities.

Opportunity space

We consider the implications of variation in the opportunity space that firms face. Characteristics of the opportunities flowing into a focal firm's environment over time may shape the distinctive ways in which individual-level knowledge aggregates to enable firm-level opportunity execution. We focus on two dimensions of prominence in prior studies: complexity and unpredictability.

Complexity. Complexity plays a particularly prominent role in work on imitation. Studies by Rivkin (2000, 2001), for example, examine the role of complexity as a barrier to imitative competition. Other work examines how complexity shapes the tradeoff between innovation and the deterrence of imitation (Ethiraj, Levinthal & Roy, 2008), its contingent effects on imitation breadth (Csaszar & Siggelkow, 2010), and its implications for knowledge flows (Sorenson, Rivkin & Fleming, 2006). More generally, because complexity serves to increase the difficulty of opportunity execution, it may have varying and non-obvious effects as a function of the differences in knowledge distribution and heterogeneity that arise from the combination of intra-firm knowledge mobilization and inter-firm imitative competition.

Unpredictability. Unpredictability, which reflects the degree to which there is a predictable structure in the stream of opportunities that arise over time in a firm's environment, holds a prominent position in work on firms in fast-moving knowledge-based environments (D'Aveni, 1994; Davis *et al*., 2009; Eisenhardt & Tabrizi, 1995). As Davis *et al.* (2009: 432) note, unpredictability captures factors such as "uncertainty, turbulence, and volatility" which collectively reflect a lack of patterning in a firm's opportunity space. Unpredictability is a central factor in contingency theory (Lawrence & Lorsch, 1967), as well as in work that builds on and extends the RBV (Barney, 1991; Wernerfelt, 1984). Work distinguishing between property-based and knowledge-based resources (Lippman & Rumelt, 1982), for example, shows that knowledge-based resources (versus property-based resources) are particularly sensitive to environmental unpredictability (Miller & Shamsie, 1996). In a setting where firms must mobilize knowledge under the threat of ongoing imitation-based competition, the degree to which opportunities that emerge vary in their degree of "patterning" is likely to influence the value of similar knowledge held by the focal firm, as well as the value to rivals of imitating this knowledge.

MODEL

Individual-level knowledge and opportunity execution

We conceptualize firms in our model as operating in a market with a continuous flow of heterogeneous opportunities (Davis *et al*., 2009). Each market opportunity has 10 binary features (e.g., a particular opportunity may be represented by the vector "1000110011"). Multiple such opportunities, differing in their pattern, flow into the environment over time, with the stochastic process generating these opportunities tunable via a set of parameters described below.

A given firm consists of a group of individuals connected through network ties, with heterogeneous knowledge distributed across these individuals that can be used to execute opportunities (Bingham & Davis, 2012; Gavetti, Levinthal & Rivkin, 2005; March, Schulz & Zhou, 2000). Each individual holds a portfolio of knowledge vectors, with each vector having 10 binary features (e.g., 1011100001). Individuals can have different knowledge portfolios: e.g., Bob may know 1001101100 and 1011100001, while Jane knows 1011100001, 1111010000 and 0000101111. Thus, individuals at any given point in time can be endowed with different quantities of knowledge (e.g., Bob knows 2 knowledge vectors, while Jane knows 3) as well as with potentially overlapping portfolios (e.g., Bob and Jane both know 1011100001).

Intra-firm network connections involve the presence or absence of a tie between any two individuals. Ties are symmetric. Thus, for an organization with N individuals the intra-organizational network is a symmetric N x N matrix with binary entries.[7] For each simulation run, we initialize firms using the Erdös-Renyi (ER) network model, the simplest method for generating random networks consisting of N nodes (individuals) and mean degree K (average number of connections per individual). For all potential pairs of individuals, this model assigns ties with equal probability, conditional on N and K. Using this random network generating model ensures that inferences are not the result of selecting a specific structure for the network. Our results are robust to values of N and K above a minimal density threshold (N>4, K>2)—i.e., where networks are partially connected with some sparseness. We model firms with N=20 and K=4, values that might represent a stereotypical entrepreneurial firm operating in a fast-moving technology-based market setting.[8]

[7] While it is possible to construct more complicated network models that, for example, incorporate variability in the strength, asymmetry, and multiplexity of ties between individuals, our model is sufficient to capture the mechanisms of theoretical interest.

[8] We examined robustness to larger and denser networks, as well as to alternative network generating models such as Ring-Lattice, Watts-Strogatz, and Barbasi, allowing us to explore the implications of our assumption of randomness in interactions. Our main insight was that a core driver of randomness in interactions relates to network structure itself. Variation in network density, defined as the average number of ties, K, per individual, N, plays a key role. Less dense networks (sometimes called "sparse" networks) lead to more randomness in interactions, as interactivity is determined by the few partners an individual happens to possess. Networks that are denser produce more predictable patterns of interactions, with the ultimate limit being that every individual could potentially access knowledge from every other member of the organization. We explored density by varying N and K, with our experiments showing that our insights are generally robust to such variation.

New opportunities arise stochastically in the environment, where they can then be discovered by the organization. The parameter P_d represents the probability that a particular opportunity will be discovered by a specific individual in each period of the simulation.[9] In the baseline model of opportunity execution that does *not* employ the knowledge mobilization mechanisms described in the next section, individuals simply apply their existing knowledge vectors to execute the opportunity. It is successfully executed when a knowledge vector held by the individual matches a sufficient number of the features of the opportunity (as determined by *complexity*, discussed below). An individual that successfully executes an opportunity is occupied (and thus unavailable to execute other opportunities) for the remainder of the period that the opportunity is available.[10]

Knowledge mobilization

As discussed in the prior section (see also Table 1), we model three knowledge mobilization mechanisms which alter the heterogeneity and distribution of knowledge within a focal firm by allowing knowledge to *move* from one individual to another (*transfer*), for individuals to *access* knowledge from other individuals to whom they are connected (collaboration), and for connected individuals to *create* new knowledge with other individuals to whom they are connected from fragments of the individuals' existing knowledge (recombination).

Transfer is conceptualized as the ongoing diffusion of knowledge between individuals connected via network ties (e.g., Argote, 1999; Hansen, 1999; Szulanski, 1996). When transfer is activated, in each time period a focal individual who discovers an opportunity will, with some probability P_t, learn a randomly selected knowledge vector from a randomly selected partner (from

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[9] While in theory multiple individuals might discover and try to execute the same opportunity, we set P_d =.01, with this relatively rare value consistent with work on opportunity discovery in dynamic markets (Kirzner, 1997; Shane, 2000).

[10] We conducted robustness checks on variation in the length of the window of opportunity. Beyond a certain level, a larger window of opportunity reduces differences between short- and long-run performance and can harm performance by occupying individuals with an excess of difficult opportunities over longer periods of time.

among those to whom the focal individual is connected). For example, if Jane and Bob are connected via a network tie, Jane can transfer 1111010000 to Bob. Once Bob knows 1111010000, he can use it to execute opportunities. In any given period, individuals can only learn from one partner at a time, consistent with the idea that knowledge transfer entails a cognitive burden on the individuals involved. Once a particular knowledge vector is transferred to an individual, it is retained by the recipient for future use.[11]

Collaboration is conceptualized as opportunity execution through the use of knowledge from an individual's network ties, consistent with work on team-based projects (e.g., Choudhury & Haas, 2018; Hansen *et al*., 2005; O'Leary *et al*., 2011). When collaboration is activated, a focal individual who discovers an opportunity in a given time period can, with probability P_c, use their partners' knowledge to execute the opportunity. For example, suppose Bob is connected to Jill, David, Maria, and Jane. If Bob discovers an opportunity, but only David has a knowledge vector that will produce a match (e.g., 1001101111), Bob would be able to mobilize Dave's knowledge vector to execute the opportunity. As such, Bob's space of available knowledge that can be applied to executing a market opportunity is expanded to include Dave's existing knowledge. In our model, we incorporate a form of knowledge accumulation: individuals who collaborate to execute an opportunity will, after the collaboration, both retain a copy of the knowledge vector.[12] In our example, this means that when Bob uses Dave's knowledge to execute an opportunity, Bob would retain Dave's knowledge vector even after the collaboration.

Recombination is conceptualized as the execution of an opportunity by combining

[11] Given that transfer occurs only from one individual to whom the focal individual is connected, and also that there may be overlap in knowledge among individuals, resulting in no net knowledge gain, our parameter settings broadly capture the essence of Szulanski's (1996) argument that transfer is rare, difficult, and not always effective in pushing knowledge around. Moreover, our concern is with transfer among individuals. An extension of our model might consider sub-units consisting of multiple individuals. In that case, knowledge transfer from one sub-unit to another might be even more difficult and rare.

[12] Retaining the knowledge vector means that either individual can then use it to execute future related opportunities. The number of opportunity features that must be matched in order for an individual to execute an opportunity is determined by the *complexity* parameter; thus, except in cases where complexity is at its highest level, knowledge accumulation will serve to expand the available base of knowledge for individuals to execute opportunities.

elements of knowledge from a focal individual and one of her partners (e.g., Fleming, 2001; Galunic & Rodan, 1998; Hargadon & Sutton, 1997). When recombination is activated, an individual will, with probability P_r, combine a randomly selected knowledge vector with one of her partners' vectors to execute the opportunity. Thus, in contrast with collaboration, where a focal individual is able to access the *existing* knowledge of a partner, in the case of recombination, *new* knowledge is created from the existing knowledge of two connected individuals, with this new knowledge then used to execute an opportunity within the space of available market opportunities. For example, Bob and Jane can create the new combination of actions 1001101111 by recombining the "10011" actions from Bob's first knowledge vector (1001101100) and the "01111" actions from Jane's third knowledge vector (0000101111) to execute the opportunity 1001101111. Just as with collaboration, we model a form of knowledge accumulation so that after recombining vectors to execute a market opportunity, both individuals retain the resulting knowledge vector.

Imitation conditions

In addition to the focal firm, we model a pool of rival firms that simultaneously execute market opportunities as they arise in the environment. Focal firm knowledge can spill-over to these rivals, at the rate P_s, representing the probability an individual in a competing organization can copy a knowledge vector from the focal firm. As discussed in the prior section, we consider variation in the following imitation conditions: *symmetry*, *absorptive capacity threshold*, and *population size*.

With *symmetry*, the imitation environment in which the focal firm and pool of rivals operate can take on one of two forms in our model. Under *asymmetric imitation*, imitation occurs in only one direction: rivals can imitate knowledge from the focal firm. By contrast, under *symmetric imitation*, a situation that represents an industry environment where imitation is much more prevalent, any organization can imitate any other organization: i.e., rivals can imitate knowledge from other rivals, and in addition, the focal firm can imitate its rivals.

With *absorptive capacity threshold*, we capture the required level of prior knowledge needed by an imitating organization to incorporate a particular knowledge vector from the focal firm (or another rival) into its knowledge base (Cohen & Levinthal, 1990). In the case of asymmetry this threshold level of absorptive capacity is relevant only to the rival population, as under asymmetry the focal firm's rivals are the only possible recipients of knowledge spillovers, and in the case of symmetry this threshold level of absorptive capacity is applicable to both the rivals and the focal firm. Conditional on a knowledge vector spilling-over to a given firm, the absorptive capacity threshold determines whether or not the imitating firm is able to capture that knowledge vector, incorporate it into its knowledge base, and use it to execute future opportunities. This allows us, therefore, to parameterize the difficulty of imitation. We define *absorptive capacity threshold* as the number of elements of a knowledge vector needed to match an existing knowledge vector held by the recipient in order for the recipient of the knowledge spillover to incorporate the knowledge into their knowledge base. A higher threshold implies that imitation is more difficult.

With *population* size, we vary the number of firms in the pool of rivals, which thus affects the intensity of competition the focal firm faces.

Opportunity space

In addition to varying the imitation conditions as described above, we also consider variation in the complexity and unpredictability of the firm's opportunity space.[13,14]

[13] We draw on Davis *et al*.'s (2009) definitions of complexity and unpredictability. Complexity refers to the number of elements that need to match in order for a firm to execute an opportunity; it thus reflects the level of difficulty in matching a knowledge vector with an opportunity (Simon, 1962). This conceptualization draws from Dess and Beard (1984) and is consistent Miller, Ogilvie and Glick's (2006) idea of numerosity underpinning complexity. Unpredictability refers to the degree of structure in the firm's knowledge environment, and also draws from Dess and Beard (1984), as well as on Miller *et al.* (2006).

[14] We also explore other characteristics of the opportunity emergence process, including velocity and the window-of-opportunity. For example, the number of opportunities that flow in each time period is determined by the Poisson arrival time distribution with rate λ (Davis *et al*., 2009). For simplicity, the velocity of opportunity flow, λ, is set to 1 per time period. In addition, consistent with

We operationalize *complexity* as the number of opportunity features that must be correctly matched in order for an individual to capture the opportunity. As an example, for an individual to use the knowledge vector 1111100010 to execute the opportunity 1011101100, six opportunity features need to be correctly matched: 1x1110xxx0. In this case, for complexity <= 6 the opportunity would be executed, while for complexity > 6 it would not. In our model, since there are 10 features for each market opportunity, the value of complexity ranges from 0 to 10. This conceptualization is consistent with prior literature viewing complexity as stemming from the number of contingencies that must be correctly realized to avoid errors and ensure proper plan execution (e.g., Lawrence & Lorsch, 1967; Simon, 1962; Sipser, 1997). E.g., in the biotechnology industry, high complexity arises from the need to correctly align a large number of opportunity features such as R&D, manufacturing, regulation, and marketing (Hill & Rothaermel, 2003).

We measure *unpredictability* with a measure of opportunity entropy (Cover & Thomas, 1991). In this measure, unpredictability is determined by the probability, for each of the 10 features in a particular market opportunity, that a particular feature is equal to 1, a value we denote by p(1) (as distinct from the probability a feature is equal to 0, p(0)). When p(1)=.5 the distribution of 1s and 0s is perfectly random (e.g., 50/50 chance of 1 or 0) and unpredictability is at its maximum, but when p(1) moves away from .5 the market becomes more predictable with a skewed ratio of 1s and 0s (e.g., 70/30 chance of 1 or 0), and unpredictability is lower. Unpredictability is measured as the entropy of opportunities: $U = - \sum p * \log_2(p)$. In our case, each element takes on two alternatives (0 or 1), so that $U = - \sum p * \log_2(p) = -p(0)* \log_2(p(0)) + -p(1)* \log_2(p(1))$ where $p(0) = 1- p(1)$. For example, when p(1)=0.7, unpredictability is relatively low with $U=-.7*\log_2(.7) + .3*\log_2(.3) = .88$. By contrast, when p(1)=0.5 (i.e., a perfectly random

work on the dynamics of heterogeneous opportunities (Adner & Levinthal, 2001; Tyre & Orlikowski, 1994) opportunities expire when their "window of opportunity" closes. The window of opportunity, W, is set to W=20 in our simulations. Variation in these two factors does not materially change our insights.

distribution of 0s and 1s), unpredictability is at its maximum value of U=1. This captures the intuition that unpredictability decreases the pattern that firms can exploit with similarly tuned knowledge (Galbraith, 1973).

ANALYSIS

The experiments we conduct with our model allow us to examine the impact of mobilizing individual-level knowledge on a focal firm's ability to capture market opportunities in the presence of imitating rivals. We center our attention on an outcome variable that captures the cumulative *number of opportunities executed* by either the focal firm or by a representative rival in a particular period. We refer to this outcome as the *performance* of the firm (whether focal or rival) in that period. We are also interested in the performance of the focal firm *relative* to its rival. We label this *competitive advantage*, which we define as focal firm performance minus the performance of a representative rival firm in a given time period.[15] In our experiments we focus first on the separate performance (i.e., number of opportunities executed) of the focal firm and a representative rival under various combinations of imitation and opportunity space. This allows us to develop insights into the dynamics shaping competitive advantage. In a final section we examine how these factors come together to influence overall focal firm competitive advantage.

In Figures 3 through 6, we report focal and representative rival firm performance in period 200. Performance levels represent the cumulative number of unique opportunities executed by the firm at period 200, with each value averaged over 100 simulation trials.[16] Period 200 represents a long-term, steady-state level of performance. In Figures 7 and 8, we then roll-up these performance levels to overall focal firm competitive advantage, plotting time series values through

[15] As noted previously, we use the terms "performance" and "competitive advantage" as shorthand for the knowledge-based firm-level outcome of opportunity execution; performance and competitive advantage in the broader sense are dependent on numerous other factors outside the scope of our model.

[16] Using a larger number of runs and time periods did not yield significantly more precision in our reported experiments.

period 500 to understand the degree to which competitive advantage is sustainable over time. The number of simulations we run is sufficiently large to obtain precise estimates, and all comparisons discussed in the text are statistically significant at the 1% level.

For each simulation run we randomly initialize the intra-organizational network, and then allow opportunities to stochastically arise in the environment with rate $\lambda=1$. Each opportunity remains in the environment for 20 periods, or until executed by an individual. The probability that an individual will discover an opportunity in any given period is tuned with the parameter P_d, set to .01 throughout our experiments. In any given set of experiments, either no mobilization mechanism is active, or one of the three mechanisms is active. When active, there is a 50% chance that each individual will engage in the mechanism in each time period.[17]

Variation in imitation conditions

Figures 3 and 4 report a first set of experiments in which we examine knowledge mobilization implications for focal and rival performance by varying three imitation conditions: (a) difficulty of imitation (*absorptive capacity*), which is captured by the degree to which the imitating firm's knowledge base needs to match that of the firm being imitated in order for imitation to occur; (b) the symmetry of the conditions under which the focal firm is competing, which determines whether it is only the focal firm that is subject to imitation (*asymmetric*) or whether all firms, including the focal as well as its pool of rivals, can imitate one another (*symmetric*); and (c) the size of the rival population (*population*).[18] Performance outcomes, as noted above, are reported averages of either focal or rival firm opportunities executed at period 200.

Absorptive capacity threshold and imitation symmetry. Figure 3 reports the effect of

[17] Our model parameters are thus set to $P_t=0.5$, $P_c=0.5$, or $P_r=0.5$ when a particular knowledge mobilization mechanism is activated. We find that our results are robust to other non-zero probabilities for these values.
[18] The rate of knowledge spillover is set to Ps=0.1 in our model. We experimented with other imitation probabilities, finding that our key insights are robust to other non-zero values. Larger values accelerate the level of unsustainability of competitive advantage.

knowledge mobilization under varying sets of competitive conditions. The four panels show the focal firm employing either no such mechanism (top left), collaboration (bottom left), transfer (top right), or recombination (bottom right). The x-axis varies the required absorptive capacity threshold. The values on the x-axis are the number of knowledge elements that need to match for a spillover to occur—as such, the left side of the axis reflects a lower difficulty of imitation, and the right side of the axis reflects a higher difficulty of imitation.[19] When the absorptive capacity threshold is lowest (left-most spot on x-axis), imitation is a function of the rate at which knowledge spillover occurs, as determined by P_s. When absorptive capacity threshold is at its highest (right-most spot on x-axis), the imitating firm must have another knowledge vector that matches *all* of the elements of the knowledge being received minus 1. The y-axis represents opportunities executed (as noted above, at period 200) for either the focal or representative rival firm. Rival population size is fixed at 4 (we vary this in later analyses).

Each panel shows focal and rival results under two sets of imitation conditions: *asymmetric*, where only the focal firm is subject to imitation by the pool of rivals; and *symmetric*, where each firm (the focal firm, along with the pool of imitating rivals) can imitate every other firm. These conditions allow us to examine the implications of knowledge mobilization under varying forms of susceptibility to imitation. We show focal and rival results for each of the two imitative conditions: the solid blue (focal) and solid red (rival) lines show the case of *asymmetry*, while the dotted blue (focal) and dotted red (rival) lines show the case of *symmetry*. Note that the rival lines depict results for a single representative rival chosen randomly from among the pool of (homogenous) rivals.

Turning first to the case of *asymmetry* (solid blue and solid red lines), we examine as a

[19] Recall that the absorptive capacity threshold captures the number of knowledge elements that need to match in order for imitation to occur. Going from left to right on the x-axis reflects an increase in this number of required matches. Thus, the lowest value of the x-axis is where imitation is least difficult; and the highest value of the x-axis is where imitation is most difficult.

baseline the case of no knowledge mobilization mechanism being employed (top-left panel of Figure 3). As that panel shows, the focal firm is at a performance disadvantage relative to a representative rival over the range of the absorptive capacity parameter space. As the absorptive capacity threshold increases (moving left to right on the x-axis), however, the focal firm closes the performance gap. This concords with intuition: in the asymmetric case, rivals imitate the focal firm, but not vice versa; thus, a focal firm not employing any form of knowledge mobilization is at a disadvantage. As imitation becomes more difficult due to an increasing threshold of absorptive capacity required for successful imitation, the gap narrows, to the point where when the absorptive capacity threshold is very high (i.e., the right-most point of the x-axis), performance of the focal and rival are roughly equivalent.

In the remaining three panels, the solid blue and solid red lines show focal and rival performance with the focal firm employing either collaboration, transfer or recombination. Turning to collaboration under asymmetric imitation, we see that the focal firm continues to under-perform for most levels of absorptive capacity threshold, although when the absorptive capacity threshold is high (right side of the x-axis), the focal firm is able to overcome the disadvantage stemming from rival imitation. When employing transfer and recombination the overall performance pattern for the focal and rival firms is similar. However, the focal firm is able to close the performance gap even at a lower absorptive capacity threshold (left side of the x-axis) in the case of transfer; and with recombination, the focal firm clearly enjoys a substantial advantage even when the absorptive capacity threshold is low.

The differences among the mechanisms in the asymmetric imitation case illustrate the point that alternative knowledge mobilization mechanisms can shift the performance balance between focal and rival. The mechanisms work in distinct ways. Both collaboration and transfer work by distributing knowledge around the firm. While collaboration enables a focal firm to access a broader knowledge base to address market opportunities (and to retain any knowledge that is then used), transfer works by moving knowledge among the inter-connected individuals within the firm. In contrast with collaboration and transfer, which alter the ways in which knowledge is *distributed* around the firm, recombination alters the *heterogeneity* of the firm's knowledge. As Figure 3 suggests, this has implications in the asymmetric imitation case for whether the firm is able to counter the downsides of imitation.

We turn next to focal and rival performance in the *symmetric* case (dotted blue and dotted red lines). In this case the focal and rival firms can all imitate one another: each firm is symmetric with respect to its ability to imitate as well as its susceptibility to imitation. When no knowledge mobilization mechanism is employed by the focal firm (top left quadrant of Figure 3), both the focal and rival firms are nearly indistinguishable. This concords with intuition, as in the absence of any knowledge mobilization mechanism, no firm is at an advantage. Moreover, as the absorptive capacity threshold increases (i.e., going from left to right, making imitation more difficult), there is no advantage to either firm: greater imitation difficulty uniformly affects focal and rivals. By contrast, when we employ any of the three knowledge mobilization mechanisms, as the absorptive capacity threshold increases and imitation becomes more difficult (moving from left to right on the x-axis), there is a point beyond which the focal firm's use of a particular knowledge mobilization mechanism counteracts the downsides of rival imitation.

Knowledge spillover-sharing. Having discussed performance separately for the focal and rival firms under alternate imitation conditions, it is informative to directly compare focal firm performance under the asymmetric and symmetric cases (i.e., the solid blue and dotted blue lines). What is surprising here is that at higher absorptive capacity thresholds—i.e., beyond a point where imitation continues to occur, but is much more difficult—a focal firm employing either transfer or recombination is better off under *asymmetric* imitation conditions (where only the focal firm is imitated) than it is under *symmetric* imitation conditions (where all rivals can be imitated as well). For the case of recombination this is true across the entire absorptive capacity threshold parameter space: a focal firm employing recombination performs uniformly better in asymmetric versus symmetric conditions.

The downside of employing recombination (and under higher levels of absorptive capacity, transfer) as the competitive environment moves from asymmetry to symmetry is puzzling, as in both cases the focal firm is being copied by rivals. In contrast with asymmetry, where the focal firm is unable to copy its rivals, in the case of symmetry the focal firm *can* copy its rivals. Thus, one would expect that allowing the focal firm to expand its knowledge portfolio by imitating rival knowledge should be a net benefit, rather than a cost, to the focal firm. The explanation lies in another aspect of *symmetric* imitation, which is that rivals can *also* copy each other as well as the focal firm. We term this a *knowledge spillover-sharing* process amongst rivals to distinguish it from simple knowledge spillover from the focal firm to its rivals. When a firm employs a knowledge mobilization mechanism such as recombination, it creates knowledge heterogeneity that benefits its pool of rivals as a whole at a greater rate than it benefits the focal firm itself.

This discussion points to a key downside associated with employing powerful knowledge mobilization mechanisms in the face of imitation: as the imitative environment shifts toward greater symmetry, investments in mechanisms such as recombination and transfer can backfire by providing greater benefits to the pool of rival firms than to the focal firm. With rival firms using this knowledge, the value to the focal firm is diminished. This is the case in particular for the heterogeneity-inducing mechanism of recombination, but also for the distribution-inducing mechanism of transfer beyond a certain absorptive capacity threshold.

[Insert Figure 3 here]

Population size. To further explore the issue of rivals capturing the benefits of the knowledge the focal firm generates, in Figure 4 we examine variation in rival population size. Whereas in Figure 3 we held population size constant at four rivals, in Figure 4 we hold the absorptive capacity threshold constant at 4, and instead vary rival population size. The panels in Figure 4 are analogous to those in Figure 3 (i.e., they represent the four knowledge mobilization situations). The x-axis varies the rival population size from 2 through 10.

As Figure 4 shows, as rival population size increases, the number of opportunities executed for both the focal and rival firm, under both sets of imitation environments, decreases. This concords with our expectation that greater levels of competition should reduce the performance of each market player. However, what is interesting is that this figure allows us to gain greater confidence in the mechanism underlying our insight that moving from asymmetry to symmetry in competitive conditions reduces the benefits to the focal firm of investments in the more powerful knowledge mobilization mechanisms such as transfer.

To understand how, it is important to underscore the key role of the entire *pool* of rival firms here: when rivals can copy one another, this effect counter-acts (and more) any benefit the focal firm gains from also being able to copy its rivals. While each individual rival effect may be small, the collective impact of a rival population is such that it eliminates many of the benefits of knowledge mobilization. Reducing the size of the rival population mitigates this downside. We can observe this effect with recombination in particular: as the rival population declines, the number of opportunities executed by the focal firm converges for the symmetric (dotted blue) and asymmetric (solid blue) cases, thus removing the knowledge spillover-sharing “penalty” for employing recombination in the symmetric case.

Taken together, the results in this sub-section illustrate that the value of employing alternative knowledge mobilization mechanisms is shaped by the symmetric (or not) nature of imitation, together with the absorptive capacity threshold required for imitation to occur. In the case of symmetry, knowledge spillover-sharing amongst rivals can result in a focal firm's rivals benefiting more than the focal firm itself from the focal firm's use of knowledge mobilization, an effect contingent on rival population size.

[Insert Figure 4 here]

Variation in complexity and unpredictability

We turn next to the implications of varying characteristics of the firm's opportunity space, focusing on complexity and unpredictability. While complexity captures the difficulty in executing opportunities, as determined by the number of elements of a knowledge vector that must match the market opportunity in order for the opportunity to be executed, unpredictability captures the degree to which opportunities flowing into the environment have a predictable structure.

Complexity. In Figure 5, we report focal and rival firm performance under levels of complexity ranging from 5 to 10. The structure of these panels mirrors Figures 3 and 4, except that the x-axis in this case is the range of complexity values, with imitative bias set at 4, population size at 4, and unpredictability such that p=0.8. We show performance of the focal firm (blue lines) and a representative rival (red lines) for the asymmetric (solid lines) and symmetric (dotted lines) conditions across each of the four knowledge mobilization cases (no mechanism, collaboration, transfer, and recombination).

Turning first to asymmetric competition, i.e., the solid blue (focal) and solid red (rival) lines, we see that at the lowest level of complexity, when there is no knowledge mobilization mechanism employed, imitation hurts the focal firm. Transfer, collaboration, and recombination, however, each enable the focal firm to close the gap between focal and rival at the low-end of the complexity range. With increasing complexity, transfer and recombination are more powerful with respect to closing the focal-rival gap. Collaboration, however, is unable to close the gap at medium levels of complexity. At the high-end of range of complexity, however, it is notable that recombination, in contrast with the other knowledge mobilization mechanisms, allows the focal firm to achieve *higher* performance levels than the rival. Thus, recombination, with its generative power that increases heterogeneity in the focal-firm knowledge base, counter-acts rival imitation.

Turning next to symmetric competition, i.e., the dotted blue (focal) and dotted red (rival) lines, we see a familiar pattern with no knowledge mobilization: focal and rival are the same. Recombination operates similar to that way it operates in the asymmetric case, except that the focal firm does relatively worse under symmetric versus asymmetric conditions at medium-high levels of complexity, a result stemming from the knowledge-spillover sharing effect noted above.

What is interesting, however, is that in the case of both collaboration and transfer under symmetric competition, the focal firm performs better than a representative rival under higher levels of complexity by employing either of these two knowledge mobilization mechanisms. Thus, knowledge mobilization benefits accruing to the focal firm are not imitable by rivals. By distributing knowledge (via collaboration and transfer) and by creating new knowledge (via recombination) in complex environments, the firm produces knowledge advantages that cannot be competed away by a pool of rivals. We return to this in our discussion of unpredictability below.

[Insert Figure 5 here]

Unpredictability. In Figure 6, we report focal and rival firm performance under levels of unpredictability ranging from p=1.0 through 0.5, so that the resulting value of unpredictability increases as we move from left to right on the x-axis.[20] The structure of these panels mirrors the previous figure, with complexity held constant at C=8, absorptive capacity threshold at 4, and population size at 4. Across the range of unpredictability values, we see patterns that echo what we found with complexity, but with important differences. Whereas an increase in complexity

[20] At the left-most point of the x-axis in each of the panels in Figure 6, p=1, and unpredictability (U) is undefined. As p declines from 1 to 0.5 (moving left to right), U increases to its maximum level. In other words, U is at its maximum level of U=1 when p=0.5, which is the right-most point on the x-axis in each of the panels.

reduced performance for both focal and rival firms, an increase in unpredictability reduces focal but not rival firm performance (under both asymmetric and symmetric competition). Thus, the rival benefits accruing as a result of imitation seem to be less sensitive to an increase in unpredictability as compared to complexity.

Unpredictability has several additional notable differences as compared to complexity. First, in contrast with greater complexity, where both collaboration and transfer lead to positive relative performance benefits for the focal firm under symmetric competition, with greater unpredictability, none of the knowledge mobilization mechanisms allow the focal firm to benefit with symmetric imitation. This is because complexity and unpredictability have distinct effects with regard to the value of the firm's knowledge base. While higher complexity simply diminishes the number of knowledge vectors that execute opportunities by making matching more difficult, greater unpredictability reduces the ability of any given pattern to be encoded in the external environment. While this does raise the difficulty of matching knowledge to opportunities, it also reduces the value of a particular pattern being encoded in a firm's knowledge base. This is important, because when employing a given knowledge mobilization mechanism, knowledge accumulation implicitly selects knowledge that is a better fit to the environmental conditions in which the firm operates: i.e., as opportunities are executed, related knowledge continues to accumulate. As unpredictability increases, however, the value of this accumulated knowledge goes down. With complexity, by contrast, the value of the knowledge is undiminished, even though difficulty of execution increases.

As a consequence, a focal firm's relative performance under symmetric competition is differentially shaped by complexity and unpredictability. The difference is a function of whether the firm's existing knowledge base is devalued or not. This explains why transfer is generally less sensitive to increasing unpredictability: devaluing knowledge has a reduced effect on transfer because knowledge selection plays a less central role in shaping the benefits of this mechanism. It also explains why the recombination benefits arising under symmetric imitation with high complexity are dissipated under higher levels of unpredictability: the benefits to complexity are most valuable when unpredictability is not too high.

Taken together, the results in this sub-section suggest that complexity and unpredictability operate in different ways to shape knowledge mobilization benefits by altering the degree to which a firm's accumulated knowledge base continues to be valuable (or not).

[Insert Figure 6 here]

Sustainability of competitive advantage

Thus far we have focused on the underlying components of competitive advantage—i.e., focal and representative rival firm performance as measured by opportunities executed. We now turn our focus to overall competitive advantage, defined as the cumulative number of opportunities executed by the focal organization, less those of an average rival organization. In contrast with prior figures where we plot performance at period 200, we show time series charts in order to track whether competitive advantage exists and persists over time.[21]

In Figure 7, the two left panels show competitive advantage under *asymmetric* competition, and the two right panels show symmetric competition. The top versus the bottom panels show differences as the absorptive capacity threshold increases (from medium to high). Turning first to the two left panels in Figure 7 (*asymmetry*), we see that at lower absorptive capacity thresholds, where imitation is easier (top left), only recombination allows the focal firm to maintain a sustainable competitive advantage. The other knowledge mobilization mechanisms, collaboration and transfer, both result in the focal firm having what can be termed a sustainable competitive *dis*advantage, although both allow the firm to benefit vis-à-vis having no such

[21] In these graphs, values above zero can be seen as competitive advantages, while those below can be seen as disadvantages.

mechanism. In the bottom left panel, we then increase the absorptive capacity threshold, thereby increasing the difficulty of imitating the focal firm. While having no knowledge mobilization mechanism continues to be competitively disadvantageous, employing the other knowledge mobilization mechanisms does allow the focal firm to retain its competitive advantage over time.

In the right two panels of Figure 7 we then show *symmetric* competition. As the top right panel illustrates, at a lower absorptive capacity threshold, employing transfer, collaboration, or no knowledge mobilization mechanism results in the focal firm's competitive advantage being indistinguishable from zero. In other words, the focal firm is unable to use its knowledge mobilization mechanisms to overcome the challenges of operating under symmetric competition. This suggests that even if the focal firm could imitate its rivals, the pool of rivals imitating each other via knowledge spillover-sharing can reduce the firm's ability to sustain competitive advantage. As imitation becomes more difficult (bottom right panel of Figure 7), competitive advantage of the various knowledge mobilization mechanisms increases. However, even then, the relative level of competitive advantage of the firm is lower than it is under asymmetric competition, suggesting that the effect of having a pool of rivals imitate the focal firm has a strong negative effect on the focal firm's ability to sustain its competitive advantage.

[Insert Figure 7 here]

In our discussion of competitive advantage thus far we have kept complexity and unpredictability constant. Because competitive advantage is most sensitive to complexity, in Figure 8 we seek to understand the implications of increasing the level of complexity. The four panels in Figure 8 are structured similarly to Figure 7, except that they set complexity to a higher level (Complexity=9, versus 8 in the prior Figure). While the increase in complexity alters the magnitude of the patterns in the top left panel, the overall pattern remains the same: recombination shows a sustainable competitive advantage over time, while the other knowledge mobilization mechanisms do not. As the absorptive capacity threshold (i.e., the difficulty of imitation) increases, however, we see that the three knowledge mobilization mechanisms *do* provide the firm with a sustainable competitive advantage. Of course, having no knowledge mobilization mechanism in the context of asymmetric imitation continues to be disadvantageous.

What is particularly interesting, however, is the implications of going from asymmetric to symmetric imitation at this higher level of complexity. Whereas with lower complexity and a lower absorptive capacity threshold (e.g., the top right panel in Figure 7) the beneficial effects of knowledge mobilization are eliminated by symmetric competition because rivals gain more from the focal firm's knowledge mobilization mechanisms than the focal firm, at higher levels of complexity these downsides are no longer apparent. This is because the value of generating heterogeneity is far greater in very difficult complex environments than the power of imitating in conditions where substantial related knowledge must be present to absorb spillovers. With recombination, the firm is able to sustain competitive advantage in the face of symmetric imitation, across varying levels of the absorptive capacity threshold.

Taken together, our results in this sub-section point to the difficulty of generating sustainable competitive advantage under conditions of imitation. Only recombination, under conditions of high complexity, has the potential to generate a longer-term sustainable advantage.

[Insert Figure 8 here]

DISCUSSION AND CONCLUSION

While the strategy literature has acknowledged the central role of individuals in the process of innovation, limited progress has been made in advancing a theory that describes how individual-level knowledge aggregates to influence firm-level outcomes. Our contribution to the strategy literature is a microfoundational theory examining the aggregation process linking individual-level knowledge to firm-level innovative opportunity execution, taking into consideration intra-firm and inter-firm interactions among individuals. Our theory illustrates how alternative design choices for mobilizing individual-level knowledge in a firm differentially shape the distribution and heterogeneity of a firm's knowledge pool, in turn influencing firm-level opportunity execution (D'Aveni *et al.*, 2010; Roy *et al.*, 2017; Wiggins & Ruefli, 2005) in the context of imitation-based competition (Ethiraj & Zhu, 2008; Knott *et al.*, 2009; Posen & Martignoni, 2018). By abstracting away from variation in knowledge tactiness (Knott, 2003; Reed & DeFillippi, 1990; Spender, 1996), a factor central to much of the prior literature on knowledge-based advantage, we generate new insights into the microfoundational underpinnings of firm-level innovation and knowledge-based competitive advantage.

We develop several theoretical insights, which derive from how knowledge mobilization shapes differences in the heterogeneity and distribution of firm knowledge under alternative imitation and opportunity space conditions, and which lend themselves to further development and testing in future empirical research. First, we find that the degree to which knowledge mobilization is beneficial depends critically on the symmetry of the competitive environment in which the focal firm operates. In more symmetric environments, investments in knowledge mobilization mechanisms can backfire, with rivals gaining more than the focal firm because of knowledge spillover-sharing amongst rivals. Second, we find that there are differences across knowledge mobilization mechanisms that arise as an outcome of the interplay between knowledge mobilization and the complex and unpredictable nature of the firm's opportunity space. These differences arise because of how different knowledge mobilization mechanisms operate—e.g., by distributing knowledge more widely throughout the firm, or by leaving the firm with a more heterogeneous knowledge base. Finally, we find that the sustainability of competitive advantage is rare, except in very particular circumstances. Even if knowledge is difficult to imitate, any advantage stemming from transfer, for example, will dissipate. In fact, it is only the recombination of complex knowledge that can potentially generate sustainable knowledge-based competitive advantage over time.

Before discussing the implications of our study for the broader strategy literature, we note some important limitations of our work which center on our focal outcomes of interest as well as on the way in which we characterize knowledge. Most importantly, our focus has been on the factors that shape opportunity execution by firms operating in the context of imitation-based competition. As such, our modeling choices focus on a narrow set of intra- and inter-firm knowledge-based factors that can influence firm-level outcomes. Consequently, the labels we ascribe to our outcomes of interest, "performance" and "competitive advantage," necessitate the important caveat that our focus is purely on (a) opportunity execution and (b) knowledge-based advantage. There are numerous other factors strategy scholars have studied that could intervene to shape the link between the execution of opportunities and competitive advantage as defined in the broader sense. In addition, our focus on knowledge is somewhat specific. We focus only on individual-level knowledge, and not on knowledge residing at the team or organizational levels; and as noted above, we abstract away from characteristics of knowledge such as its tacitness. While these caveats and limitations impose boundary conditions on the interpretation of our results, they have also allowed us to uncover a set of theoretical mechanisms that strategy scholars may seek to further understand, perhaps by considering their interaction with the factors we have held constant in this study.

In addition to these important limitations, it is helpful to explicitly highlight some of the underlying assumptions driven by our modeling choices. These assumptions may be relaxed in future studies. One set of assumptions relates to our focus on opportunity execution, which implicitly suggests that the primary threat faced by firms is not keeping up with competitive opportunities. Related to this is the assumption that opportunities are independent of one another insofar as the execution of any given opportunity by one individual does not directly affect the execution of an opportunity by other individuals, nor does it affect the ability of the firm to take advantage of future opportunities. Future work extending our model could consider the implications of interdependencies with respect to opportunity execution both within a particular time period, as well as inter-temporally. A second set of assumptions relates to network topology. Whereas we assume a fixed network structure, future work might consider the possibility of an endogenous feedback loop as individuals form and strengthen or dissolve their own ties. Finally, a third set of assumptions is that the costs of upfront investment for the various knowledge mobilization mechanisms have already been borne: i.e., our analysis focuses on ongoing opportunity costs that individuals bear when they forgo other opportunities because they are currently engaged in opportunity execution. Yet cost considerations may be salient when comparing competing organizations that must each decide whether to invest in these mechanisms, with uncertainty as to whether their competitor has already done so. This issue, likewise, offers another opportunity to build on and extend our insights.

Beyond the extensions implied by the boundary conditions and assumptions embedded in our study, there are a number of implications for future research across several streams of the strategy literature, including work on organization design and dynamic capabilities. In the domain of organization design, for example, recent work has advanced our understanding of how factors such as information processing and intra-firm governance shape the provision and use of knowledge within firms (e.g., Joseph *et al*., 2018; Joseph & Gaba, forthcoming; Puranam, Alexy and Reitzig, 2014; Rivkin & Siggelkow, 2003). Our insights may thus inform how these underlying design choices might fare under alternative imitation conditions and varying levels of opportunity complexity and unpredictability.

With regard to the literature on dynamic capabilities (e.g., Eisenhardt & Martin, 2000;

Helfat & Peteraf, 2003; Teece, 2007; Zott, 2003), we show that knowledge, which underlies firm capabilities, has performance implications that are contingent on the competitive and market conditions in which the firm is situated. Activities that allow firms to create, extend, and modify capabilities are, of course, the provenance of managers, as described in work on dynamic managerial capabilities (Adner & Helfat, 2003; Helfat & Martin, 2015; Martin, 2011). Managers may use their dynamic managerial capabilities to put in place processes that shape the nature and extent of knowledge mobilization. Consequently, the location and timing of knowledge mobilization may be an outcome of a firm's dynamic managerial capabilities.

In conclusion, we use computational modeling to develop a microfoundational theory describing the aggregation processes that link individual-level knowledge to firm-level innovative opportunity execution. Our theory highlights the dynamic interplay between knowledge mobilization, imitation, and characteristics of the opportunity space within which firms operate. In so doing we advance our understanding of the microfoundations of knowledge-based advantage, providing insights that can guide future empirical studies on this important topic.

ACKNOWLEDGEMENTS

The authors thank the Editor, Connie Helfat, and two anonymous reviewers, for their thoughtful feedback throughout the review process.

REFERENCES

Adner, R., & Helfat, C. E. 2003. Corporate effects and dynamic managerial capabilities. ***Strategic Management Journal***, 24(10): 1011-1025.

Adner, R., & Levinthal, D. 2001. Demand heterogeneity and technology evolution: Implications for product and process innovation. ***Management Science***, 47(5): 611-628.

Almeida, P., & Kogut, B. 1999. Localization of knowledge and the mobility of engineers in regional networks. ***Management Science***, 45(7): 905-917.

Ancona, D. G., & Caldwell, D. F. 1992. Bridging the boundary: External activity and performance in organizational teams. ***Administrative Science Quarterly***, 37(4): 634-665.

Argote, L. 1999. ***Organizational Learning: Creating, Retaining and Transferring Knowledge***. Norwell, MA: Kluwer Academic Publishers.

Argote, L., & Fahrenkopf, E. 2016. Knowledge transfer in organizations: The roles of members, tasks, tools, and networks. ***Organizational Behavior and Human Decision Processes***, 136: 146-159.

Argote, L., & Ingram, P. 2000. Knowledge transfer: A basis for competitive advantage in firms. ***Organizational Behavior and Human Decision Processes***, 82(1): 150-169.

Argote, L., & Ren, Y. 2012. Transactive memory systems: A microfoundation of dynamic capabilities. ***Journal of Management Studies***, 49(8): 1375-1382.

Arora, A., & Gambardella, A. 2010. The market for technology. In B. H. Hall & N. Rosenberg (Eds.), ***Handbook of the Economics of Innovation, Vol. 1***: 641-678. Amsterdam, The Netherlands: Elsevier.

Audretsch, D. B., & Feldman, M. P. 1996. R&D spillovers and the geography of innovation and production. ***The American Economic Review***, 86(3): 630-640.

Baker, T., & Nelson, R. E. 2005. Creating something from nothing: Resource construction through entrepreneurial bricolage. ***Administrative Science Quarterly***, 50(3): 329-366.

Barney, J. 1991. Firm resources and sustained competitive advantage. ***Journal of Management***, 17(1): 99-120.

Barney, J., & Felin, T. 2013. What are microfoundations?. ***Academy of Management Perspectives***, 27(2): 138-155.

Beckman, C. M., & Haunschild, P. R. 2002. Network learning: The effects of partners' heterogeneity of experience on corporate acquisitions. ***Administrative Science Quarterly***, 47: 92-124.

Bingham, C. B., & Davis, J. P. 2012. Learning sequences: Their emergence, evolution, and effect. ***Academy of Management Journal***, 55(3): 611-641.

Bresnahan, T. F., & Reiss, P. C. 1991. Entry and competition in concentrated markets. ***Journal of Political Economy***, 99(5): 977-1009.

Brown, S. L., & Eisenhardt, K. M. 1997. The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations. ***Administrative Science Quarterly***, 42(1): 1-34.

Burton, R. M., & Obel, B. 1995. The validity of computational models in organization science: From model realism to purpose of the model. ***Computational and Mathematical Organization Theory***, 1(1): 57-72.

Caner, T., Cohen, S. K., & Pil, F. 2017. Firm heterogeneity in complex problem solving: A knowledge-based look at invention. ***Strategic Management Journal***, 38(9): 1791-1811.

Carnabuci, G., & Operti, E. 2013. Where do firms' recombinant capabilities come from? Intraorganizational networks, knowledge, and firms' ability to innovate through technological recombination. ***Strategic Management Journal***, 34(13): 1591-1613.

Choudhury, P., & Haas, M. R. 2018. Scope versus speed: Team diversity, leader experience, and patenting outcomes for firms. ***Strategic Management Journal***, 39(4): 977-1002.

Coff, R., & Kryscynski, D. 2011. Drilling for micro-foundations of human capital–based competitive advantages. ***Journal of Management***, 37(5): 1429-1443.

Cohen, W. M., & Levinthal, D. A. 1990. Absorptive capacity: A new perspective on learning and innovation. ***Administrative Science Quarterly***, 35(1990): 128-152.

Cover, T., & Thomas, J. 1991. ***Elements of Information Theory***. New York: Wiley.

Csaszar, F., & Siggelkow, N. 2010. How much to copy? Determinants of effective imitation breadth. ***Organization Science***, 21(3): 661-676.

D'Aveni, R. A. 1994. ***Hypercompetition: Managing the Dynamics of Strategic Maneuvering***. New York: Free Press.

D'Aveni, R. A., Dagnino, G. B., & Smith, K. G. 2010. The age of temporary advantage. ***Strategic Management Journal***, 31(13): 1371-1385.

Dahlander, L., O'Mahony, S., & Gann, D. M. 2016. One foot in, one foot out: How does individuals' external search breadth affect innovation outcomes?. ***Strategic Management Journal***, 37(2): 280-302.

Davis, J. P., Eisenhardt, K. M., & Bingham, C. B. 2007. Developing theory through simulation methods. ***Academy of***

Management Review, 32(2): 480-499.

Davis, J. P., Eisenhardt, K. M., & Bingham, C. B. 2009. Optimal structure, market dynamism, and the strategy of simple rules. ***Administrative Science Quarterly***, 54(3): 413-452.

Demsetz, H. 1973. Industry structure, market rivalry, and public policy. ***The Journal of Law and Economics***, 16(1): 1-9.

Dess, G., & Beard, D. 1984. Dimensions of organizational task environments. ***Administrative Science Quarterly***, 29(1): 52-73.

Eisenhardt, K. M., & Martin, J. A. 2000. Dynamic capabilities: What are they? ***Strategic Management Journal***, 21(10-11): 1105-1121.

Eisenhardt, K. M., & Tabrizi, B. N. 1995. Accelerating adaptive processes: Product innovation in the global computer industry. ***Administrative Science Quarterly***, 40(1): 84-110.

Ethiraj, S. K., Levinthal, D., & Roy, R. R. 2008. The dual role of modularity: Innovation and imitation. ***Management Science***, 54(5): 939-955.

Ethiraj, S. K., & Zhu, D. H. 2008. Performance effects of imitative entry. ***Strategic Management Journal***, 29(8): 797-817.

Felin, T., Foss, N. J., & Ployhart, R. E. 2015. The microfoundations movement in strategy and organization theory. ***The Academy of Management Annals,*** 9(1): 575-632.

Felin, T., & Hesterly, W. S. 2007. The knowledge-based view, nested heterogeneity, and new value creation: Philosophical considerations on the locus of knowledge. ***Academy of Management Review,*** 32(1): 195-218.

Fleming, L. 2001. Recombinant uncertainty in technological search. ***Management Science***, 47(1): 177-132.

Galbraith, J. 1973. ***Designing Complex Organizations***. Reading, MA: Addison-Wesley.

Galunic, D. C., & Rodan, S. 1998. Resource recombinations in the firm: Knowledge structures and the potential for schumpeterian innovation. ***Strategic Management Journal***, 19(12): 1193-1201.

Garg, P., & Zhao, M. 2018. Knowledge sourcing by multidivisional firms. ***Strategic Management Journal***, 39(13): 3326-3354.

Gavetti, G., Levinthal, D., & Rivkin, J. W. 2005. Strategy-making in novel and complex worlds: The power of analogy. ***Strategic Management Journal***, 26(8): 691-712.

Gibson, C., & Vermeulen, F. 2003. A healthy divide: Subgroups as a stimulans for team learning behavior. ***Administrative Science Quarterly***, 48(2): 202-239.

Greve, H. R. 2009. Bigger and safer: The diffusion of competitive advantage. ***Strategic Management Journal***, 30(1): 1-23.

Grigoriou, K., & Rothaermel, F. T. 2014. Structural microfoundations of innovation: The role of relational stars. ***Journal of Management,*** 40(2): 586-615.

Gupta, A. K. & Govindarajan, V. 2000. Knowledge flows within multinational corporations. ***Strategic Management Journal***, 21(4): 473-496.

Haas, M. R., & Hansen, M. T. 2007. Different knowledge, different benefits: Toward a productivity perspective on knowledge sharing in organizations. ***Strategic Management Journal***, 28(11): 1133-1153.

Hansen, M. T. 1999. The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. ***Administrative Science Quarterly***, 44(1): 82-111.

Hansen, M. T. 2002. Knowledge networks: Explaining effective knowledge sharing in multiunit companies. ***Organization Science***, 13(3): 232-248.

Hansen, M. T., Mors, M. L., & Lovas, B. 2005. Knowledge sharing in organizations: Multiple networks, multiple phases. ***Academy of Management Journal***, 48(5), 776-793.

Hargadon, A., & Sutton, R. I. 1997. Technology brokering and innovation in a product development firm. ***Administrative Science Quarterly***, 42(4): 716-749.

Helfat, C. E., Finkelstein, S., Mitchell, W., Peteraf, M. A., Singh, H., Teece, D. J., & Winter, S. G. 2007. ***Dynamic Capabilities: Understanding Strategic Change in Organizations.*** Malden, MA: Blackwell Publishing.

Helfat, C. E., & Martin, J. A. 2015. Dynamic managerial capabilities: Review and assessment of managerial impact on strategic change. ***Journal of Management***, 41(5): 1281-1312.

Helfat, C. E., & Peteraf, M. A. 2003. The dynamic resource-based view: Capability lifecycles. ***Strategic Management Journal***, 24(10): 997-1010.

Henderson, R., & Cockburn, I. 1996. Scale, scope, and spillovers: The determinants of research productivity in drug discovery. ***RAND Journal of Economics***, 27(1): 32-59.

Hill, C. W. L., & Rothaermel, F. T. 2003. The performance of incumbent firms in the face of radical technological innovation. ***Academy of Management Review***, 28(2): 257-274.

Hsu, D. H., & Lim, K. 2014. Knowledge brokering and organizational innovation: Founder imprinting

effects. ***Organization Science***, 25(4): 1134-1153.
Joseph, J., Baumann, O., Burton, R. & Srikanth, K. 2018. Reviewing, revisiting, and renewing the foundations of organization design. In ***Advances in Strategic Management: Organization Design***. Bigley, UK: Emerald Group Publishing Limited.
Joseph, J., & Gaba, V. The fog of feedback: Ambiguity and firm responses to multiple aspiration levels. ***Strategic Management Journal***, forthcoming.
Karim, S., & Kaul, A. 2015. Structural recombination and innovation: Unlocking intraorganizational knowledge synergy through structural change. ***Organization Science***, 26(2): 439-455.
Katila, R., & Ahuja, G. 2002. Something old, something new: A longitudinal study of search behavior and new product introduction. ***Academy of Management Journal***, 45(6): 1183-1194.
Kirzner, I. 1997. Entrepreneurial discovery and the competitive market process: An Austrian approach. ***Journal of Economic Literature***, 35(1): 60-85.
Knott, A. M. 2003. The organizational routines factor market paradox. ***Strategic Management Journal***, 24(10): 929-943.
Knott, A. M., Posen, H. E., & Wu, B. 2009. Spillover asymmetry and why it matters**.** ***Management Science***, 55(3): 373-388.
Lawrence, P. R., & Lorsch, J. W. 1967. ***Organization and Environment: Managing Differentiation and Integration***. Boston, MA: Harvard University Press.
Lippman, S. A., & Rumelt, R. P. 1982. Uncertain imitability: An analysis of interfirm differences in efficiency under competition. ***The Bell Journal of Economics***, 13(2): 418-438.
March, J. G., Schulz, M., & Zhou, X. 2000. ***The Dynamics of Rules: Change in Written Organizational Codes***. Palo Alto, CA: Stanford University Press.
Martin, J. A. 2011. Dynamic managerial capabilities and the multibusiness team: The role of episodic teams in executive leadership groups. ***Organization Science***, 22(1): 118-140.
Martin, J. A., & Eisenhardt, K. M. 2010. Rewiring: Cross-business-unit collaborations in multibusiness organizations. ***Academy of Management Journal***, 53(2): 265-301.
McEvily, S. K., & Chakravarthy, B. 2002. The persistence of knowledge-based advantage: An empirical test for product performance and technological knowledge. ***Strategic Management Journal***, 23(4): 285-305.
Miller, C. C., Ogilvie, D. T., & Glick, W. H. 2006. Assessing the external environment: an enrichment of the archival tradition. In D. J. Ketchen & D. D. Bergh (Eds.), ***Research Methodology in Strategy and Management:*** 97-122. Bingley, UK: Emerald Group Publishing Limited.
Miller, D., & Shamsie, J. 1996. The resource-based view of the firm in two environments: The Hollywood film studios from 1936 to 1965. ***Academy of Management Journal***, 39(3): 519-543.
Mors, M. L. 2010. Innovation in a global consulting firm: When the problem is too much diversity. ***Strategic Management Journal***, 31(8): 841-872.
Mortensen, M., & Haas, M. R. 2018. Perspective-rethinking teams: From bounded membership to dynamic participation. ***Organization Science***, 29(2): 341-355.
Nerkar, A., & Paruchuri, S. 2005. Evolution of R&D capabilities: The role of knowledge networks within a firm. ***Management Science***, 51(5): 771-785.
Obstfeld, D. 2005. Social networks, the tertius iungens orientation, and involvement in innovation. ***Administrative Science Quarterly***, 50(1): 100-130.
O'Leary, M. B., Mortensen, M., & Woolley, A. W. 2011. Multiple team membership: A theoretical model of its effects on productivity and learning for individuals and teams. ***Academy of Management Review***, 36(3): 461-478.
Owen-Smith, J., & Powell, W. W. 2003. Knowledge networks as channels and conduits: The effects of spillovers in the Boston biotechnology community. ***Organization Science***, 15(1): 5-21.
Phelps, C., Heidl, R., & Wadhwa, A. 2012. Knowledge, networks and knowledge networks: A review and research agenda. ***Journal of Management*** 38(4): 1115-1166.
Posen, H. E., Lee, J., & Yi, S. 2013. The power of imperfect imitation. ***Strategic Management Journal***, 34(2): 149-164.
Posen, H. E., & Martignoni, D. 2018. Revisiting the imitation assumption: Why imitation may increase, rather than decrease, performance heterogeneity. ***Strategic Management Journal,*** 39(5): 1350-1369.
Puranam, P., Alexy, O., & Reitzig, M. 2014. What's "new" about new forms of organizing?. ***Academy of Management Review***, 39(2): 162-180.
Reagans, R., & McEvily, B. 2003. Network structure and knowledge transfer: The effects of cohesion and range. ***Administrative Science Quarterly***, 48(2): 240-267.
Reed, R., & DeFillippi, R. J. 1990. Causal ambiguity, barriers to imitation, and sustainable competitive

advantage. ***Academy of Management Review***, 15(1): 88-102.
Rindova, V., & Kotha, S. 2001. Continuous morphing: Competing through dynamic capabilities, form, and function. ***Academy of Management Journal***, 44(6): 1263-1280.
Rivkin, J. W. 2000. Imitation of complex strategies. ***Management Science***, 46(6): 824-844.
Rivkin, J. W. 2001. Reproducing knowledge: Replication without imitation at moderate complexity. ***Organization Science***, 12(3): 274-293.
Rivkin, J. W., & Siggelkow, N. 2003. Balancing search and stability: Interdependencies among elements of organizational design. ***Management Science***, 49: 290-311.
Roy, R., Lampert, C. M., & Stoyneva, I. 2018. When dinosaurs fly: The role of firm capabilities in the 'avianization'of incumbents during disruptive technological change. ***Strategic Entrepreneurship Journal,*** 12(2): 261-284.
Saxenian, A. 1994. ***Regional Advantage: Culture and Competition in Silicon Valley and Route 128***. Cambridge, MA: Harvard Univ. Press.
Shane, S. 2000. Prior knowledge and the discovery of entrepreneurial opportunities. ***Organization Science***, 11(4): 448-469.
Simon, H. A. 1962. The architecture of complexity. ***Proceedings of the American Philosophical Society***, 106: 467-482.
Singh, J. 2005. Collaborative networks as determinants of knowledge diffusion patterns. ***Management Science***, 51(5): 756-770.
Singh, J., & Fleming, L. 2010. Lone inventors as sources of breakthroughs: Myth or reality? ***Management Science***, 56(1): 41-56.
Sipser, M. 1997. ***Introduction to the Theory of Computation***. Boston, MA: PWS Publishing.
Sorenson, O., Rivkin, J. W., & Fleming, L. 2006. Complexity, networks and knowledge flow. ***Research Policy***, 35(7): 994-1017.
Spender, J. C. 1996. Making knowledge the basis of a dynamic theory of the firm. ***Strategic Management Journal,*** 17(S2): 45-62.
Szulanski, G. 1996. Exploring internal stickiness: Impediments to the transfer of best practice within the firm. ***Strategic Management Journal***, 17(Winter Special Issue): 27-43.
Szulanski, G., & Jensen, R. J. 2006. Presumptive adaptation and the effectiveness of knowledge transfer. ***Strategic Management Journal***, 27: 937-957.
Taylor, A., & Greve, H. R., 2006. Superman or the fantastic four? Knowledge combination and experience in innovative teams. ***Academy of Management Journal***, 49(4): 723-740.
Teece, D. J. 2007. Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. ***Strategic Management Journal***, 28(13): 1319-1350.
Toh, P. K., & Polidoro, F. 2013. A competition-based explanation of collaborative invention within the firm. ***Strategic Management Journal***, 34(10): 1186-1208.
Tsai, W. 2001. Knowledge transfer in intraorganizational networks: Effects of network position and absorptive capacity on business unit innovation and performance. ***Academy of Management Journal***, 44(5): 996-1004.
Tyre, M. J., & Orlikowski, W. J. 1994. Windows of opportunity: Temporal patterns of technological adaptation in organizations. ***Organization Science***, 5(1): 98-118.
Vroom, G., & Gimeno, J. 2007. Ownership form, managerial incentives, and the intensity of rivalry. ***Academy of Management Journal,*** 50(4): 901-922.
Wernerfelt, B. 1984. A resource-based view of the firm. ***Strategic Management Journal***, 5(2): 171-180.
Wiggins, R. R., & Ruefli, T. W. 2005. Schumpeter's ghost: Is hypercompetition making the best of times shorter?. ***Strategic Management Journal***, 26(10): 887-911.
Winter, S. G. 1987. Knowledge and competence as strategic asset. In D. J. Teece (Ed.), ***The Competitive Challenge: Strategies for Industrial Innovation and Renewal***. Cambridge, MA: Bellinger.
Zander, U., & Kogut, B. 1995. Knowledge and the speed of the transfer and imitation of organizational capabilities: An empirical test. ***Organization Science***, 6(1): 76-92.
Zott, C. 2003. Dynamic capabilities and the emergence of intra-industry differential firm performance: Insights from a simulation study. ***Strategic Management Journal***, 24(2): 97-125.

Table 1. Summary of Knowledge Mobilization Mechanisms

	Core Process	Representative Studies Examining Process	Model Functioning	Firm Knowledge Implications
Transfer	**Movement** of knowledge from one individual to another on an ongoing basis	Zander & Kogut (1995), Szulanski (1996), Argote (1999), Argote & Ingram (2000), Tsai (2001), Reagans & McKevily (2003)	Ongoing, passive transfer of knowledge among connected individuals, not tied to specific opportunity	Distribution of knowledge is increased over time due to ongoing inter-individual knowledge movement
Collaboration	**Access** to the knowledge space of other individuals to whom a focal individual is connected	Ancona & Caldwell (1992), Hansen, Mors & Lovas (2005), Haas & Hansen (2007), Martin & Eisenhardt (2010), Mors (2010), O'Leary, Mortensen & Woolley (2011), Choudhury & Haas (2018), Mortensen & Haas (2018)	Search space of individual knowledge is expanded to include knowledge of connected individuals in order to match an opportunity in the environment	Distribution of knowledge is increased when opportunity is executed due to knowledge accumulation
Recombination	**Creation** of new knowledge from existing knowledge of connected individuals	Hargadon & Sutton (1997), Galunic & Rodan (1998), Fleming (2001), Katila & Ahuja (2002), Obstfeld (2005), Taylor & Greve (2006), Carnabuci & Operti (2013), Hsu & Lim (2014), Karim & Kaul (2015)	Connected individuals recombine two randomly selected knowledge vectors to create new knowledge in order to match an opportunity in the environment	Heterogeneity of knowledge is increased when opportunity is executed, with executed knowledge accumulated by individuals

Figure 1:
A Model of Heterogeneous Opportunity Execution with Distributed Knowledge

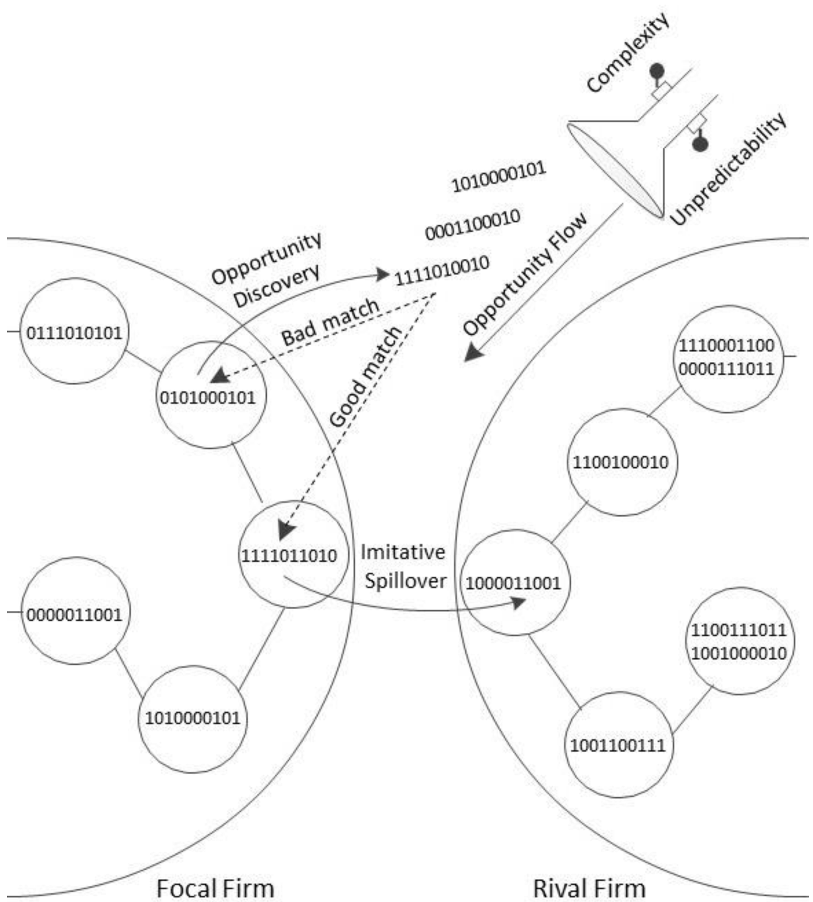

Figure 2:
Knowledge Mobilization Mechanisms in Opportunity Execution

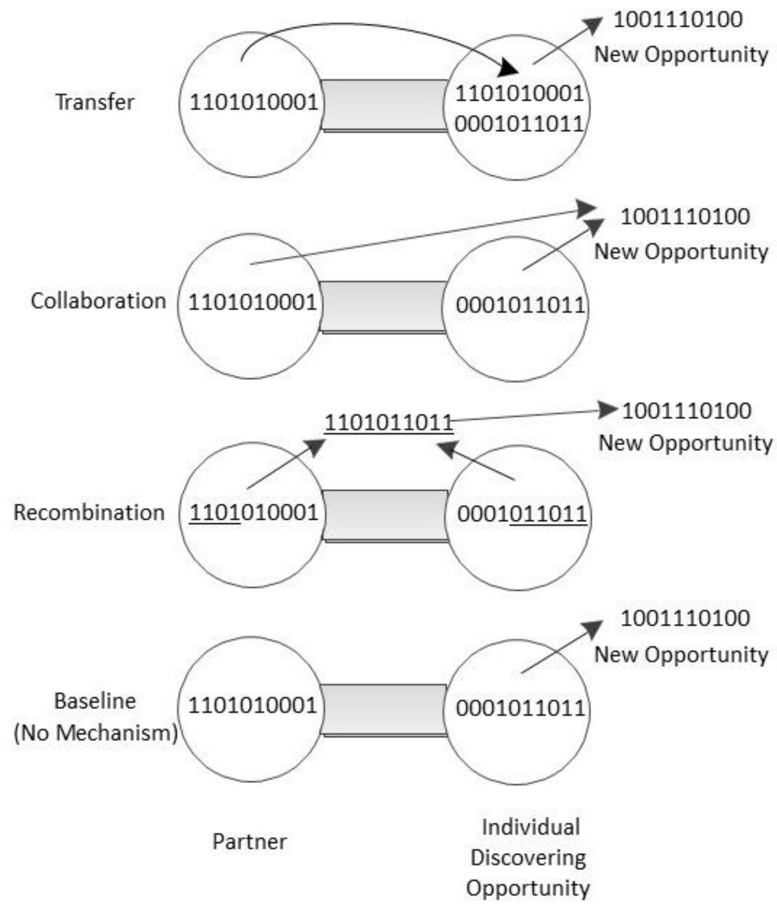

Figure 3. Opportunities Executed – Varying Absorptive Capacity Threshold

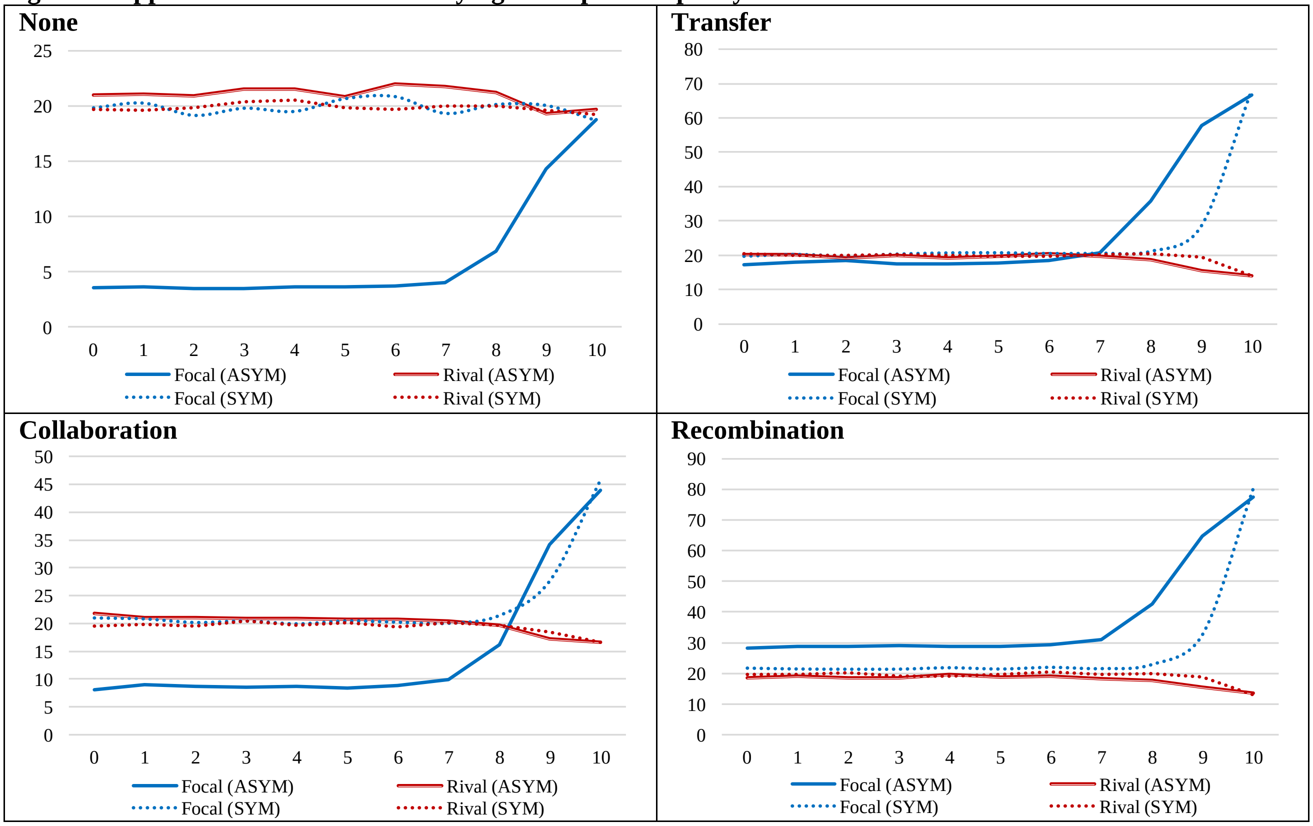

Figure 4. Opportunities Executed – Varying Population Size

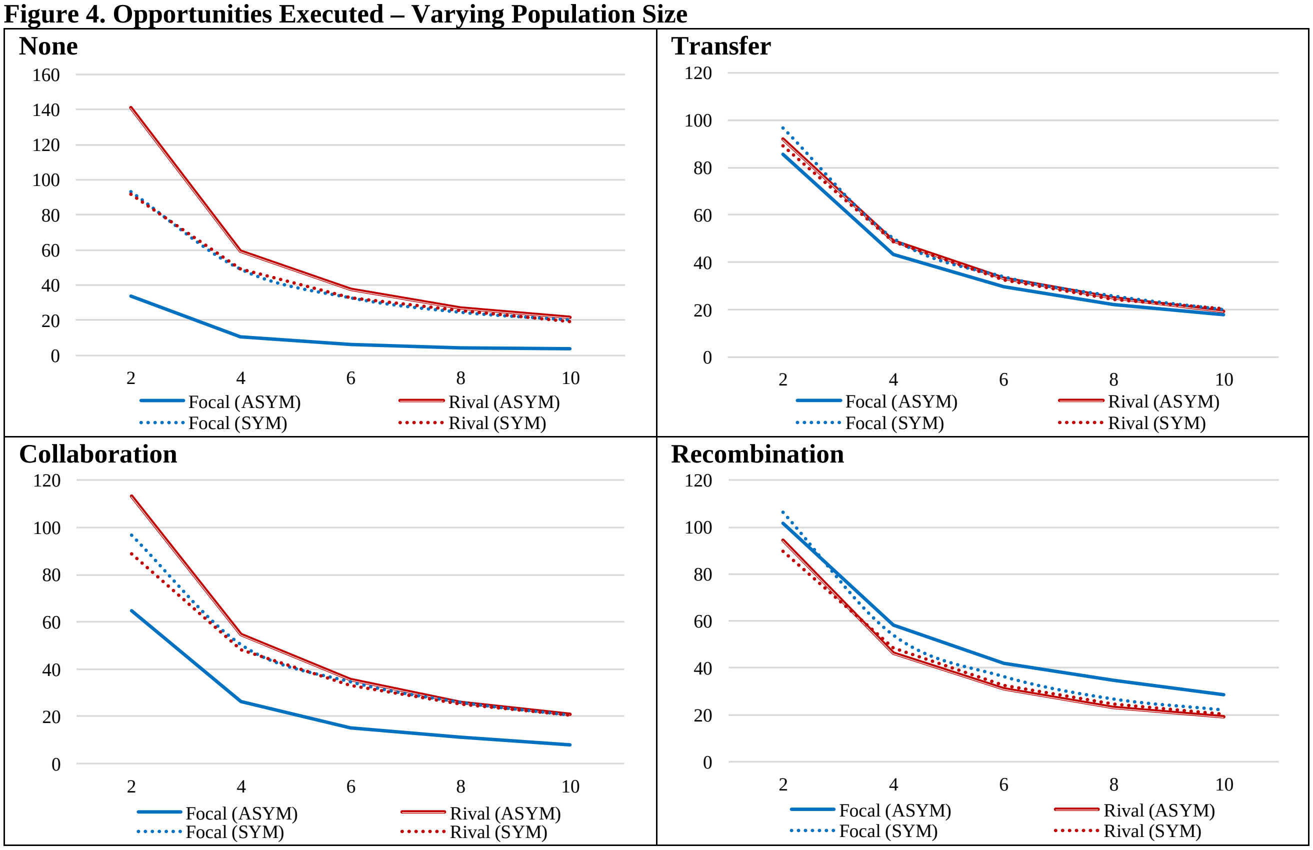

Figure 5. Opportunities Executed – Varying Complexity

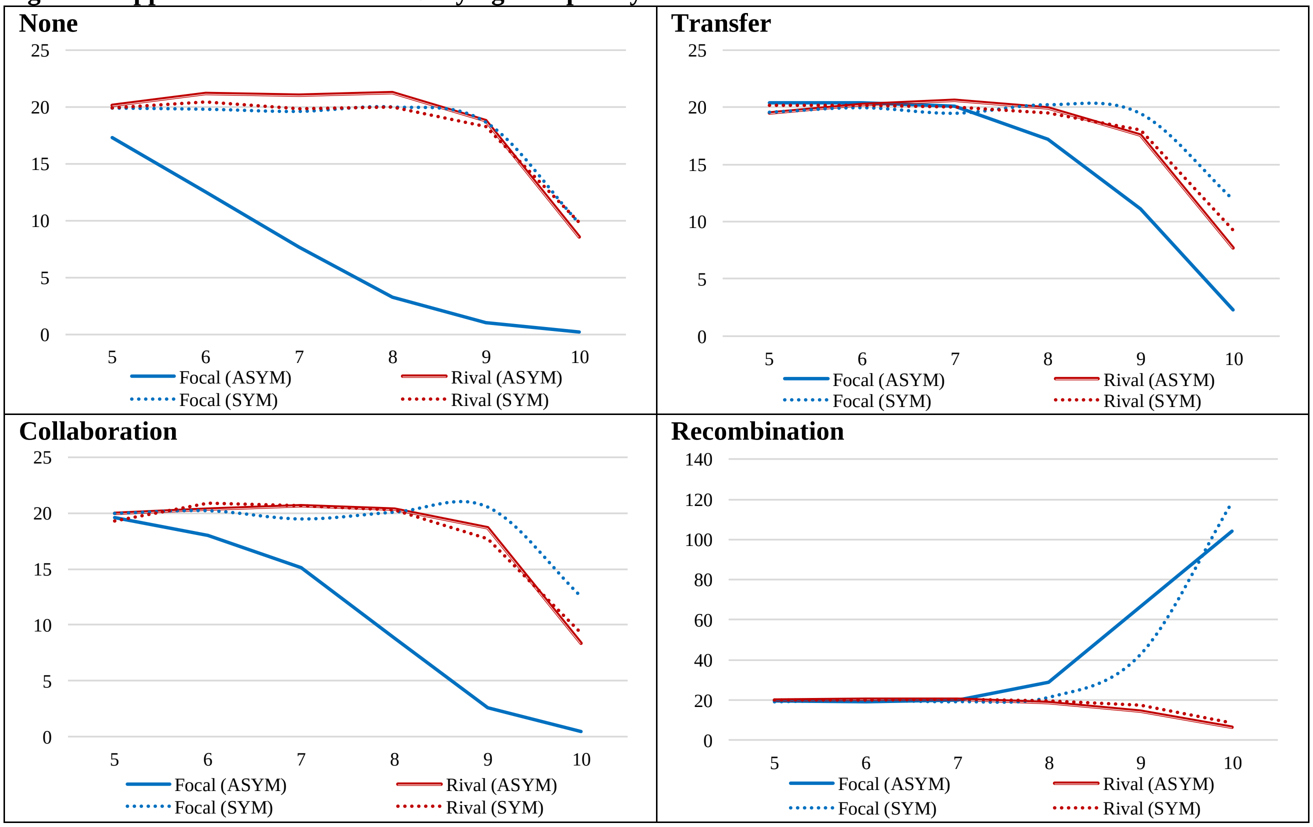

Figure 6. Opportunities Executed – Varying Unpredictability

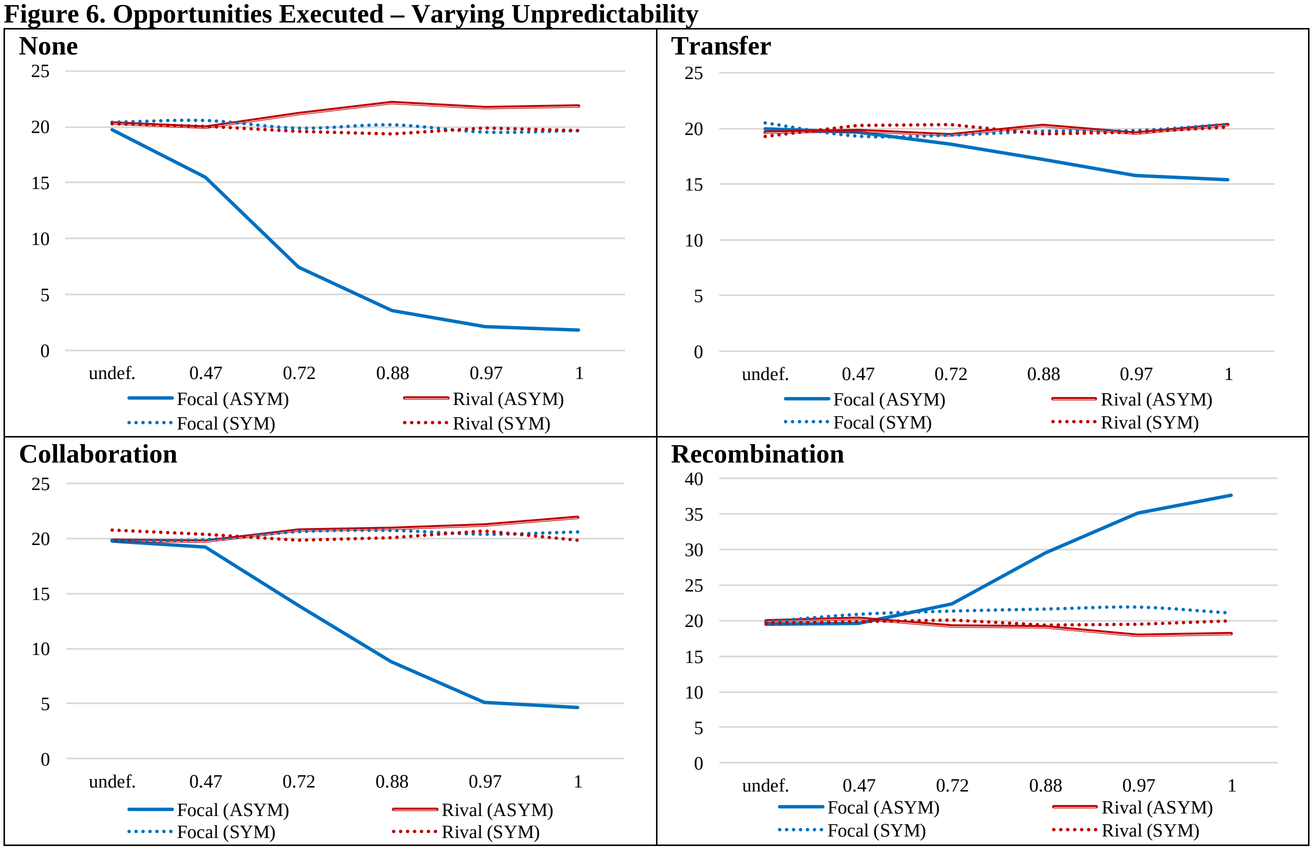

Figure 7. Sustainability of Competitive Advantage, Complexity=8

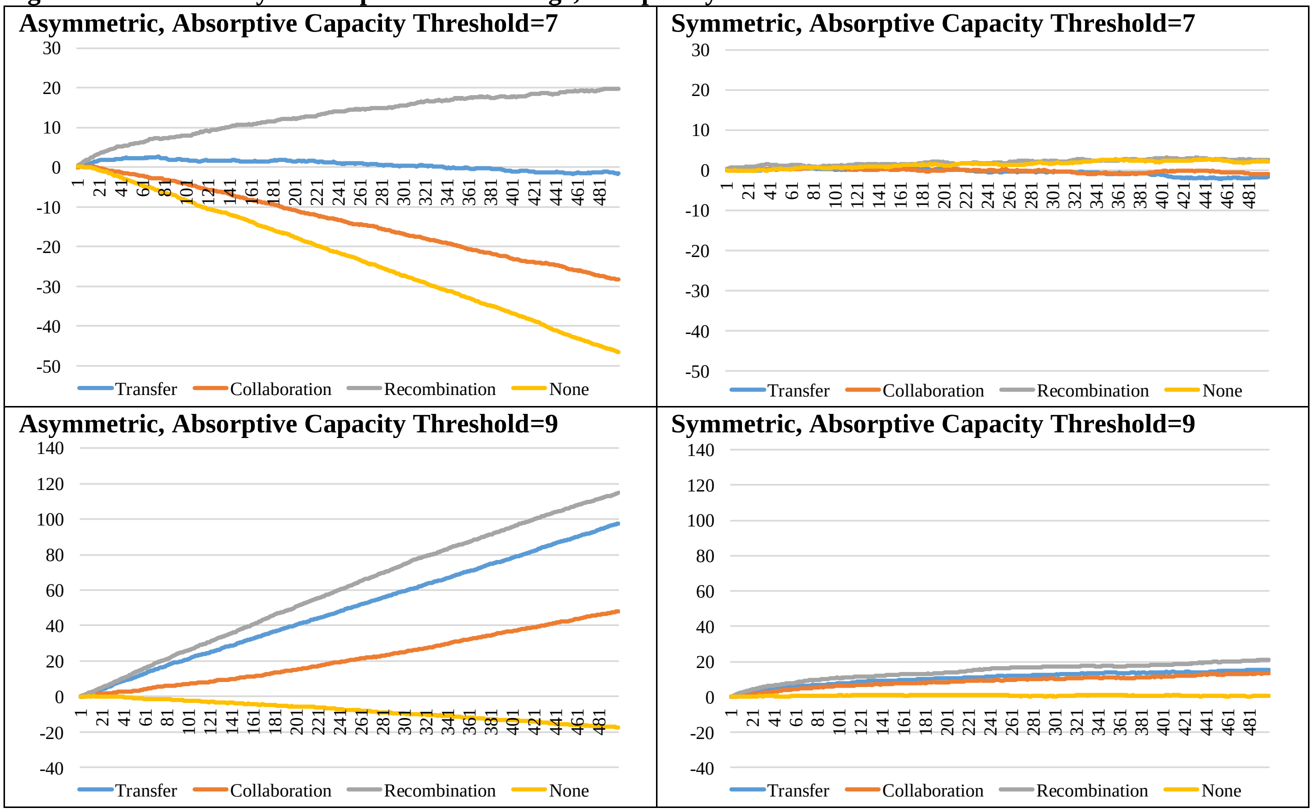

Figure 8. Sustainability of Competitive Advantage, Complexity=9