ADAPTATION ACROSS MULTIPLE LANDSCAPES:

RELATEDNESS, COMPLEXITY, AND THE LONG RUN EFFECTS OF COORDINATION IN DIVERSIFIED FIRMS

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Introduction

The study of coordination costs—the costs of managing multiple business lines within a single firm—is a topic of central importance to corporate strategy research. Building off transaction cost theory (Williamson, 1975; 1985; 1991), scholars have long argued that bureaucratic costs of coordinating between businesses set the limits to corporate diversification (Hill, Hitt, and Hoskisson, 1992; Nayyar, 1992). Firms will diversify to the point where the marginal synergies from further diversification equal the marginal increase in bureaucratic costs (Jones and Hill, 1988), and these costs will increase with the interdependence between businesses, so that firms diversifying into related businesses may be better off choosing a more limited scope than unrelated diversifiers (Zhou, 2011). While research in this area has traditionally focused on the short run costs of

coordination—including bureaucratic costs of communication and information flow (Jones and Hill, 1988; Gulati and Singh, 1998; Zhou, 2011), monitoring costs and incentive distortions (Williamson, 1975; 1985; Riordan and Williamson, 1985; Hill et al., 1992), and comparison costs (Nickerson and Zenger, 2008; Obloj and Zenger, 2017)—recent scholarship has also recognized that the coordination of activities between businesses may have consequences for the ability of diversified firms to adapt over time (Rawley, 2010). This work argues that firms operating in multiple businesses may make choices that are optimal for the overall firm but suboptimal for individual businesses, so coordination may impose an additional 'cost' in the form of organizational rigidity (Rawley, 2010; de Figueiredo, Rawley, and Rider, 2015; Natividad and Rawley, 2016).

In this study, we extend this line of research by theoretically examining how coordination between businesses in diversified firms impacts their adaptation. We argue that coordination of related activities between businesses may increase rigidity within each business, since the business will no longer be free to make changes to that activity based on its needs alone; at the same time, coordination of activities between businesses may also enhance cross-business learning, with knowledge and best practices discovered in one business being shared with another (Miller, Fern, and Cardinal, 2007; Williams, 2007). The net long-run effect of coordination on the performance of diversified firms thus depends on the relative magnitude of these rigidity and learning effects. Where the rigidity effects dominate the learning effects, the very coordination that enables diversified firms to realize synergies between businesses may also inhibit the adaptation of those businesses over time. Thus, while diversified firms may enjoy a performance advantage relative to their focused counterparts in the short run, this advantage may decline—and potentially turn negative—in the

long run. The diversified firm still realizes synergies between businesses, but the benefit of these synergies is (partially or wholly) offset by the weaker performance of each business due to its failure to adapt as effectively as its more focused counterparts.

We further argue that the relative magnitude of these rigidity and learning effects, and therefore the net long run effect of coordination between businesses on diversified firm performance, will depend on the relationships between the firm's activities. More specifically, we build on prior work that has highlighted the effect of interdependence within a business—i.e., complexity—on organizational adaptation (Levinthal, 1997; Gavetti and Levinthal, 2000; Siggelkow and Levinthal, 2003) by examining how complexity within businesses interacts with interdependence between businesses—i.e., relatedness—to impact adaptation in diversified firms. First, we expect that coordination between businesses will increase with their relatedness, given the greater potential for synergies, thus increasing both rigidity and cross-business learning in the long run. Second, we argue that complexity will amplify the rigidity effects of coordination, with coordination between businesses constraining not only those activities that are coordinated between businesses, but also those activities that depend on these coordinated activities (Claussen et al., 2015). At the same time, increasing complexity may boost the benefits of cross-business learning, as the greater difficulty of adaptation within businesses makes cross-business learning more valuable (Siggelkow and Levinthal, 2003; Claussen et al., 2015).

We study the joint effect of relatedness and complexity on the performance of diversified firms over time using a simulation based approach. Specifically, we develop a modified version of

the NK model (Levinthal, 1997) in which a diversified firm searches over two landscapes while coordinating choices between them, and compare the performance of this diversified firm to the (combined) performance of two focused firms, each searching on a single landscape. The results from our simulation show that coordination between businesses has a negative long-run effect on a diversified firm's performance relative to that of its single business counterparts—i.e., diversified firms face long run coordination costs—with this negative effect having a nonlinear relation with both relatedness and complexity. The negative long run consequences of coordination increase with relatedness, but at a decreasing rate, eventually starting to decline as cross-business learning between highly related businesses becomes increasingly valuable. In the presence of complexity, therefore, coordination between businesses is most harmful for adaptation at moderate levels of relatedness. We also find a nonlinear relationship between these long run negative effects and complexity: modest levels of complexity impose severe constraints on a diversified firm's ability to adapt, but increases in complexity beyond moderate levels have little additional effect.

Having examined the effects of relatedness and complexity on the adaptation of diversified firms, we then extend our analysis to consider the short run synergies (net of bureaucratic costs) from coordination between businesses. Two key findings emerge from this analysis. First, we find that the optimal number of activities between businesses that a diversified firm should coordinate is generally less than the number of related activities (i.e., activities with positive potential synergies) between them, with this gap being greater for more complex businesses. Rather than exploiting every potential synergy, diversified firms may be better off realizing only a handful of the most important synergies between businesses, leaving the rest untapped. In the extreme, firms in complex

businesses may be better off not diversifying at all. This is because the loss of potential synergies in the short run is more than compensated for by the long run benefits of superior adaptation. Second, we find that, given complexity, the long run advantage of diversified firms has a curvilinear relationship with relatedness: the performance advantage of moving from low to moderate relatedness is substantially less than that of moving from moderate to high relatedness.

These findings contribute to corporate strategy research in a number of ways. First, we develop and extend the idea that coordination between businesses in diversified firms may be a source of rigidity, moving beyond recent empirical work that has documented rigidity in diversified firms (Rawley, 2010; Natividad and Rawley, 2016) to examine how the long run costs of coordination between businesses in diversified firms increase with both relatedness and complexity (Burgelman, Snihur, and Thomas, 2018). By highlighting the role of complexity in driving rigidity, we not only show that interdependence within businesses may cause the performance of diversified firms to vary in nonlinear ways, we also help connect this work to the broader literature on organizational adaptation in the face of complexity (Levinthal, 1997; Ethiraj and Levinthal, 2004; Claussen et al., 2015). Second, we shift the focus from the question of how widely a firm should diversify its portfolio of businesses (Jones and Hill, 1988; Zhou, 2011) to the question of how deeply it should coordinate within that portfolio. While prior work has focused on the problem of excessive diversification (Markides, 1992; 1995), arguing and showing that diversified firms may underperform if they enter too many businesses (Palich, Cardinal, and Miller, 2000), our findings point to a problem of excessive coordination, suggesting that diversified firms may underperform if the quest for synergies causes them to coordinate too much between any two businesses. Diversified firms

thus face a potential trade-off between maximizing synergies in the short run or maintaining flexibility in the long run. Third, our findings highlight a potential advantage of conglomerate diversification, showing that, in the presence of complexity, diversification into largely unrelated businesses may be no worse—and potentially better—in the long run than diversification into moderately related businesses. They also suggest that firms in highly complex businesses may be better off not diversifying at all. These findings thus extend recent work examining the implications of within business complexity for organizational scope and structure choices (Weigelt and Miller, 2013; Brahm and Tarzijan, 2016). Finally, we rigorously model the long run effects of coordination between businesses, considering not only the short run economies of scope and bureaucratic costs from coordinating between businesses, but also the long run rigidity and learning effects from coordinating activities between businesses, thus providing a stronger theoretical foundation for further exploration of questions around the strategy, structure, and performance of diversified firms.

Theoretical background

Relatedness, coordination, and adaptation in diversified firms

Scholars of strategy and organization have long been interested in the costs of hierarchical governance and the limits they impose on firm scope (Coase, 1937; Penrose, 1959; Williamson, 1975; 1985; 1991). In particular, prior work has emphasized the role that costs of coordination play in setting the limits to corporate diversification (Jones and Hill, 1988; Zhou, 2011). While diversified firms may realize economies of scope from sharing resources and capabilities between related businesses (Rumelt, 1974; 1982; Montgomery and Wernerfelt, 1988; Yao, 1988; Chatterjee and

Wernerfelt, 1991; Markides and Williamson, 1994; Miller, 2006; Levinthal and Wu, 2010), the realization of these scope economies will require coordination within the firm's hierarchy (Teece, 1980; 1982), and such coordination will give rise to bureacratic costs (Williamson, 1975; 1985; Jones and Hill, 1988). Thus, firms should only diversify to the point where the additional synergies from entering a marginal business equal the increase in bureaucratic costs from doing so (Jones and Hill, 1988); diversification beyond this optimal level is likely to result in declining performance (Markides, 1992; 1995; Palich et al., 2000). Moreover, these bureaucratic costs may vary with both the nature of diversification (Nayyar, 1992) and the structure of the organization (Hill et al., 1992)—specifically, they may increase with the extent of relatedness between businesses, with the result that firms diversifying into more related areas may choose a more limited scope (Zhou, 2011). These costs may include the costs of communication and information transfer (Jones and Hill, 1988; Zhou, 2011), costs of incentive degradation (Williamson, 1985; Riordan and Williamson, 1985; Hill and Hoskisson, 1987; Hoskisson, Hitt and Hill, 1991; 1993), influence activities (Milgrom, 1988; Alonso, Dessein, and Matouschek, 2008) and agency (Jensen and Meckling, 1976; Amihud and Lev, 1981; 1999; Denis, Denis, and Sarin, 1997; 1999), costs of inter-unit conflict (Porter, 1985; Argyres, 1995), and comparison costs of envy between units (Nickerson and Zenger, 2008; Rawley and Simcoe, 2010; Larkin, Pierce, and Gino, 2012; Obloj and Zenger, 2017). As shown in Figure 1, coordination between businesses in a diversified firm thus produces both (intra-temporal[1]) economies of scope

[1] Since we are focused on the benefits and costs of coordinating between businesses, we do not consider inter-temporal economies of scope that arise from redeployment across businesses (Helfat and Eisenhardt, 2004; Levinthal and Wu, 2010; Sakhartov and Folta, 2015; 2016) in our analysis.

and bureaucratic costs in the short run[2], with firms only choosing to diversify and coordinate across businesses if the former dominates the latter.

Insert Figure 1 about here

In addition to these costs and benefits, which impact diversified firm performance in the short run, coordination between businesses may also have longer run effects. In particular, recent scholarship has highlighted the potential for diversification to increase organizational rigidity (Rawley, 2010; de Figueiredo et al., 2015). Decisions in individual businesses within diversified firms may be "sublimated to serve the greater good of the overall firm" (Rawley, 2010; p. 873), and this may create barriers to successful adaptation, as the choices firms make to realize economies of scope between businesses constrain their ability to adapt successfully within businesses (Natividad and Rawley, 2016)[3]. Coordination between businesses, while enabling firms to realize synergies in the short run, may thus compromise the performance of individual businesses, and therefore of the firm as a whole, in the long run.

Coordination across businesses may also produce additional long run benefits for diversified firms. A key advantage of coordination is the potential for businesses to learn from each other over time. Firms that successfully adapt will seek to replicate the outcomes of successful adaptation

[2] This does not mean that economies of scope and bureaucratic costs matter only in the short run; only that they are realized relatively soon after coordination starts, and continue as long as coordination continues. In practice, moreover, some economies of scope and bureaucratic costs may take a few periods to be realized, while some of the long run effects of coordination we discuss next may become apparent fairly quickly; the distinction between short and long run in Figure 1 is therefore best thought of as a continuum.

[3] This is not to suggest that diversified firms cannot change their choices in individual businesses, only that when choosing to do so they will need to consider not only the impact on the focal business but also the impact on the related business. To the extent that making a change in one business means sacrificing the (net) synergies between businesses, diversification thus raises the threshold for changes within a business, slowing adaptation.

internally (Nelson and Winter, 1982; Rivkin, 2001; Zollo and Winter, 2002) and this may apply not only to replication across similar units within a single business firm, but also to transfer and replication between units of related businesses within a diversified firm (Miller et al., 2007; Williams, 2007; Kim and Anand, 2018). First, in so far as resource or capability is shared between businesses in such a firm, any enhancement of that resource or capability through innovation will benefit the performance of both businesses. Both businesses may thus enjoy economies of learning (Yao, 1988) as a consequence of coordination between them. Second, a routine or best practice developed in one business may be shared with a related business within the firm. Coordination between businesses may thus allow each business to make discoveries—either jointly for coordinated activities or through knowledge transfer between businesses whose activities are coordinated—it may not otherwise have made on its own (Markides and Williamson, 1994)[4]. In this way, coordination between businesses, while harmful for autonomous adaptation, may be beneficial for cooperative adaptation (Williamson, 1991; Alonso, Dessein, and Matouschek, 2015; Claussen et al., 2015). Figure 1 shows these two long run effects of coordination in diversified firms: a rigidity effect (which acts as a cost, reducing performance), and a cross-business learning effect (which benefits performance).

Whether coordination benefits or hurts the performance of a diversified firm in the long run depends on which of these effects dominates. Even if the rigidity effect dominates the learning effect—meaning that the net long run effect of coordination is negative—that does not necessarily

[4] Note that neither of these mechanisms of cross-business learning involve taking a resource or capability out of one business and placing it in another; i.e., they are benefits of coordination rather than redeployment between businesses. Even though they accrue over the long run, these cross-business learning benefits are thus distinct from inter-temporal economies of scope (Helfat and Eisenhardt, 2004).

mean that the diversified firm underperforms focused firms in the long run; only that its relative advantage declines. Since the diversified firm will continue to enjoy the benefits of economies of scope between businesses (net of bureaucratic costs) as a result of coordination, it may still be better off coordinating between businesses in the long run, just not as well off as it was in the short run. Moreover, even if the effect of rigidity were to make a firm underperform its focused counterparts in the long run, the firm may not always correct course, given the adjustment costs of changing coordination (Argyres, Bigelow and Nickerson, 2015; Argyres, Mahoney, and Nickerson, 2018). First, in many cases, the choices firms make regarding coordination may be hard to reverse, given investments in specialized capabilities and ongoing commitments linked to those choices (Ghemawat, 1991). Second, even if the investments linked to the firm's choices are sunk, path dependence may make adjustments to firm capabilities costly in the short run (Leonard-Barton, 1992; Levinthal and March, 1993; Lee, 2008). A firm that chose to separate activities that were previously coordinated would experience an immediate drop in synergies, but the benefits of better adaptation within each business would take time to accrue, resulting in short term losses for the firm (Natividad and Rawley, 2016). Moreover, separating businesses that were previously linked together may prove disruptive, even if the coordination between them was yielding few synergies (Feldman, 2014; Karim and Kaul, 2015), further lowering short run performance. Third, it may be cognitively challenging to discern that the shortfall in firm performance is a consequence of coordination, especially in the presence of high levels of interdependence within and between businesses (Kaplan and Henderson, 2005). At any point in time, the firm will be able to clearly observe the contemporaneous benefits of coordination in the form of realized synergies, but may find it hard to

discern the gradual decline in its performance in each business as a consequence of coordination.

Role of complexity

These long run effects of coordination—rigidity and learning—will not only depend on the extent of relatedness (and hence the extent of coordination) between businesses, they may also be moderated by the extent of interdependence between different activities within each business, i.e., its complexity (Thompson, 1967; Porter, 1985; Milgrom and Roberts, 1995; Siggelkow, 2002; Weigelt and Miller, 2013; Burgelman et al., 2018). The prior literature has long emphasized the role of complexity in increasing organizational rigidity by causing firms to get stuck at local optima (Levinthal, 1997; Gavetti and Levinthal, 2000; Rivkin, 2000; Siggelkow and Levinthal, 2003; 2005; Rivkin and Siggelkow, 2007), and shown that such interdependence within businesses has implications for firm performance (Lenox, Rockart, and Lewin, 2010; Lee and Alnahedh, 2016). It seems only natural to extend the insights from this work to a diversified firm setting.

In order to do so, we conceptualize each business of the firm as a value chain of activities (Porter, 1985; Helfat and Raubitschek, 2000; Qian, Agarwal, and Hoetker, 2012)—manufacturing, marketing, R&D, procurement, etc.—each supported by a (operational) capability that allows it to perform that activity (Helfat et al., 2007; Helfat and Winter, 2011). Note that, for our purposes, we think of capabilities quite broadly—to include physical assets and resources, knowledge, and routines, as well as bundles of these together—whatever enables the firm to complete an activity in a reliable and minimally satisfactory manner (Winter, 1995; Helfat and Winter, 2011). Firms make choices on individual activities by investing in changing or maintaining their capabilities, in an

attempt to maximize the performance of the overall firm. Interdependence within businesses refers to relationships between different activities within the same business, meaning that the performance consequences of the firm's choices on one activity is a function of its choice on others. This in turn means that the capabilities associated with these choices may need to be co-specialized (Williamson, 1975; Argyres and Zenger, 2012; Kaul, 2013). We define the *complexity* of each business as the number of such interdependencies within it (Weigelt and Miller, 2013). Similarly, we define the *relatedness* of any two businesses as the extent of interdependence between them. Interdependence between businesses refers to the potential relationships between corresponding activities in different businesses, meaning that the performance consequences of the firm's choice on the focal activity in one business is similar to that in the other. This in turn means that the firm may benefit from coordinating that activity between businesses, in order to realize economies of scope (Teece, 1980; 1982; Miller, 2006; Levinthal and Wu, 2010; Hart and Holmstrom, 2010). Figure 2 provides a simple illustration of this conceptualization for a firm operating in two businesses (A & B), with three value chain activities (1, 2, and 3) in each business.

Insert Figure 2 about here

The simple representation in Figure 2 points to the ways in which complexity may impact adaptation in diversified firms. On one hand, it suggests that complexity may amplify rigidity (Rawley, 2010; Natividad and Rawley, 2016). If choices on activities within a business are linked to each other (Porter, 1985; Siggelkow, 2002), then a constraint on any one of those choices potentially serves as a constraint on them all (Wu et al., 2014; Kapoor and Furr, 2015). It follows that in a

complex setting, coordination between businesses on an activity does not simply constrain the choice on that activity, it impacts the choices on all other activities that are linked to the coordinated activity. For instance, choosing to coordinate activities A1 and B1 between the two businesses in Figure 2 would not only constrain the firm's choices on those two activities, it would also impact choices on activities A2, B2, and B3.

As an example of such amplification of rigidity, consider the case of Motorola's entry into semiconductors, as described in Holbrook et al. (2000). While Motorola did not coordinate its technology choices between its new semiconductor business and its legacy business, it did seek to leverage its legacy relationship with the military when entering semiconductors. In particular, Motorola chose to focus on hybrid technologies rather than thin film and monolithic devices because "hybrid technology's reliability, relatively low price, and suitability for its main customer recommended it to Motorola" (Holbrook et al, 2000; p. 1024). And even when Motorola did eventually pursue more advanced technologies, its attempts to do so were "hampered by its geographic isolation from the new Northern California semiconductor center" and the fact that its "corporate research connections were with companies no longer on the technology frontier" (Holbrook et al., 2000; p. 1024); in other words, by choices—its Phoenix location, its partnership with RCA and Bell Labs—it had made at the behest of the military. Thus, Motorola's technology choices in semiconductors were constrained by its coordination of customer relationships with its other business, even though the technology choices themselves were specific to semiconductors.

On the other hand, complexity may also enhance the benefits of learning across businesses,

as increasing complexity makes replication more valuable (Rivkin, 2001). More specifically, coordination between businesses, and the resulting imitation of one business's choices in the other, may benefit the firm in two ways (Csaszar and Siggelkow, 2010). First, to the extent that the two businesses are similar, the firm may benefit from mimicking combinations of choices between businesses (Csaszar and Siggelkow, 2010). As complexity increases, finding the optimal combination of choices across activities within a business becomes more challenging (Levinthal, 1997; Gavetti and Levinthal, 2000), so if a diversified firm is able to transfer the knowledge of how best to combine resources (Helfat and Raubitschek, 2000; Qian et al., 2012) from one business to another, this may give it an advantage relative to its focused counterparts. Second, diversified firms may benefit from the dislodging effect of coordination on adaptation within each business (Csaszar and Siggelkow, 2010). As prior work has shown, mechanisms that draw search away from local optima—such as unnecessary linkages between modules (Siggelkow and Levinthal, 2003), environmental shocks (Claussen et al., 2015), and imperfect imitation (Posen, Lee, and Yi, 2013)—may prove beneficial in contexts with high complexity. Coordination of activities between businesses may thus serve to dislodge or 'scramble' search activities within businesses, resulting in stronger performance.

A simulation based approach

The preceding discussion suggests that coordination between businesses may either enable or hinder the adaptation of businesses in a diversified firm, and that complexity within businesses may either amplify or ameliorate this effect. The net implications of coordination between businesses in the presence of both relatedness and complexity for the long run performance of

diversified firms are thus hard to determine using verbal theory alone. We therefore choose to adopt a simulation based approach to investigate these effects further. Doing so allows us to consider a wide range of values for key underlying drivers, while controlling for other factors that may impact the performance of diversified firms. We are thus able to clearly isolate the effect of coordination between businesses on long run firm performance, as well as the moderating effect of complexity on this main effect. We are also able to consider a full range of potential values of complexity within and relatedness between businesses in a way that would be hard to do empirically[5]. Moreover, a simulation based approach allows us to formally explore the combined effect of multiple factors that may drive diversified firm adaptation in a systematic way, thus enabling more rigorous development of theory. Finally, using a simulation allows us to build on and connect with prior theoretical work that has explored adaptation in single business firms (Levinthal, 1997; Gavetti and Levinthal, 2000; Ethiraj and Levinthal, 2004).

Multiple landscapes and business relatedness

In order to model adaptation in diversified firms, we start with the basic NK landscape set-up used in prior work (Levinthal, 1997; Rivkin and Siggelkow, 2007), i.e., we model a firm searching on a landscape of $N = 12$ binary choices with the outcome of each choice depending upon the value of K other choices, where $0 \leq K < N$ is thus a parameter reflecting the complexity of the business (details of the NK model framework we use can be found in online Appendix A). We

[5] It may be the case, for instance, that relatedness and complexity are negatively correlated in practice, with businesses that are more complex being less likely to be closely related to other businesses. If such a correlation existed, it would make it difficult to empirically separate the effects of relatedness and complexity, even though they are conceptually orthogonal. One advantage of the simulation is that it allows us to consider the full range of possible values of our parameters of interest, without having to assume, or being limited by, a relation between them.

adopt this set-up because it is the canonical simulation model for studying firm adaptation in the face of complexity, and has been widely used for this purpose in the prior literature (Levinthal, 1997; Siggelkow and Levinthal, 2003; Sorenson, 2003; Ethiraj and Levinthal, 2004; Claussen et al. 2015).

Since we are interested in studying adaptation in diversified firms, however, we modify this set-up by including not one but two landscapes. Specifically, we consider two related NK landscapes of the same structure, without loss of generality. To model relatedness, we utilize a parameter R which captures the number of elements that have similar contribution functions in both landscapes (Csaszar and Siggelkow, 2010), with R taking values between 0 and N. This reflects the idea that relatedness will mean similarity of activities between businesses, so that choices that work well in one business will also work well in the other. Rather than assume that all R activities are exactly the same across landscapes, we model a sliding scale of similarity, with the first element being the most similar across landscapes, the second less similar, and so on[6]. More specifically, for any value of R, we assume the contribution function for the *i*th element of the second landscape is given by $\alpha c + (1-\alpha)c'$ where c is the contribution of the *i*th element of the first landscape, c' is the contribution of the *i*th element of a randomly generated alternate landscape with same value of N and K as the first landscape, and $\alpha = 1 - \frac{i-1}{R}\ for\ 0 < i \leq R; 0\ for\ R < i \leq N$. When R is zero, the two businesses are independent, and there is no relationship between the performance of any elements across the two landscapes. As relatedness increases, the landscapes start to look more similar. For parsimony, we assume that both landscapes have the same K, i.e., they are both equally

[6] For simplicity, and without loss of generality, we assume that the elements are arranged in the order of decreasing relatedness.

complex[7].

Local search

Consistent with prior work (Levinthal, 1997), we model firms as boundedly rational actors (Simon, 1947), undertaking local search on these landscapes, i.e., evaluating alternatives adjacent to their current position, and choosing the first alternative that has better performance. Specifically, it means that firms search by randomly changing exactly one element of their current configuration. If the performance of the new configuration is superior to that of their existing configuration then the new configuration is adopted; if not, then the current configuration is retained, and the firm tries a different alternative in the next period. Search ends where all local alternatives have been evaluated, and none of them has a higher performance.

For diversified firms, this procedure is modified in that instead of searching on one landscape the firm searches on both landscapes simultaneously. The search process continues to be local, in that the firm evaluates changes in one element at a time[8]. However, we assume that the decisions between the two landscapes are coordinated; specifically, we define a parameter L of the extent of this coordination, such that the choices on the first L elements have to be consistent, i.e., if the firm changes one of the L elements on one landscape, it has to simultaneously change the same

[7] We also assume that the structure of interdependence is the same across both businesses, though as we discuss later, our results are robust to relaxing this assumption. Note also that this assumption does not mean that the actual interdependence is the same across businesses. Because of the way we model contribution functions, the payoffs from the same choices in different businesses are different. We are only assuming that the same sets of activities that are interdependent in one business are also interdependent in the other; the extent of their interdependence still varies.
[8] To avoid giving the focused firms a substantial processing power advantage—letting them make two decisions for every one the diversified firm makes—we allow the diversified firm to make two choices for every one made by each focused firm. Note that this does not impact the steady state that the firms achieve, which is what we are principally concerned with in our analyses.

element on the other landscape as well. This assumption reflects the need for coordination in order for the potential synergies between businesses to be realized (Hart and Holmstrom, 2010; Zhou, 2011). We begin by considering the case where the firm coordinates all related activities, i.e., $L = R$, though we relax this assumption later in our analysis[9].

Synergies

To model synergies, we introduce a parameter $\delta \geq 0$, which captures the net short run synergies from coordinating activities between businesses for the diversified firm, i.e., it captures the economies of scope from the sharing of capabilities (Rumelt, 1974; Montgomery and Wernerfelt, 1988; Yao, 1988; Levinthal and Wu, 2010) less bureacratic costs (Williamson, 1985; Jones and Hill, 1988)[10]. Specifically, we assume that the firm realizes synergies equal to $\delta\alpha c$ for every element i it coordinates (i.e., every $i \leq L$), and only for those elements, consistent with our assumption that coordination is necessary to realize synergies. This implies that the extent of synergies realized is proportional to the similarity between the activities in the two landscapes; the logic being that the extent to which the firm can share capabilities related to that activity between the two businesses (and therefore the extent to which it can realize economies of scope) is limited by the extent of

[9] In general, we assume that $L \leq R$, i.e., a firm will not coordinate activities unless they are (at least somewhat) similar. This follows logically from the assumption that coordinating unrelated activities produces no synergistic benefits ($\alpha = 0 \; for \; R < i \leq N$); in the absence of such benefits, it makes no sense for the firm to constrain itself by coordinating unrelated activities between businesses.

[10] We assume that $\delta \geq 0$, i.e., coordination costs are not greater than economies of scope. If this were not the case, the firm would have no incentive to diversify in the first place. Put differently, we assume that a firm will only coordinate activities between businesses if the economies of scope from doing so are equal to or greater than the resulting coordination costs. This is also a reason for assuming that $L \leq R$; for values of $L > R$ coordination costs would presumably exceed economies of scope, making coordination beyond that point sub-optimal.

similarity between the activities[11]. For the purposes of our analysis, we examine values of $\delta = 0, \frac{1}{2N}, \frac{1}{N}, \frac{3}{2N}$ as reflecting reasonable levels of net synergies[12]. With high enough synergies diversification is always the dominant choice; we therefore confine our analysis to a range of parameter values where the net short run synergies and long run effects of coordination are potentially comparable in magnitude.

Diversified firm advantage

We compute the performance advantage of a diversified firm by comparing its performance to that of two single business firms[13]. Specifically, we calculate diversification advantage as the difference between a diversified firm's performance and the combined performance of two equivalent single business firms independently searching on each landscape, as a proportion of the focused firms' performance. Our approach is thus analytically similar to the 'chop-shop' approach used in the diversification discount literature (Lang and Stulz, 1994; Villalonga, 2004). To study how diversification advantage changes with relatedness and complexity, we run our simulation at levels of K ranging from 0 to 11 and R ranging from 1 to 12[14]. The reported results for each combination of K and R are the average of 100 randomly generated simulation runs where in each run the

[11] Making synergies a function of α also means that synergies increase with coordination at a decreasing rate. As online Appendix B shows, our main findings are robust to making synergies independent of α, or making α independent of R

[12] Intuitively, a value of $\delta = \frac{1}{N}$ means that the capability is 8.33% more productive on average in each business as a result of being shared, even after accounting for the coordination costs associated with sharing.

[13] For ease of presentation, the results presented below normalize performance by setting the value of the global peak on each landscape to 1. Our findings are unchanged if we use non-normalized scores

[14] In the interests of parsimony, the results below show only the simulations corresponding to K =2, 6, and 10, i.e., low complexity, moderate complexity, and high complexity respectively. Results for other values of K (available from the authors) are consistent with the pattern shown by these values. We also do not plot values of $R = 0$ since, by definition, there is no difference between a diversified firm and its focused counterparts in that case.

performance of 100 firms are aggregated (Levinthal, 1997). In common with most of the NK literature, we do not consider competition between firms in our simulation (though see Lenox, Rockart, and Lewin, 2006; 2007 for noteworthy exceptions). Our measure of diversification advantage is thus best thought of as a measure of the advantage of diversified firms in terms of their internal efficiency or productivity, rather than their profitability per se.

Analyses and findings

Complexity, relatedness and the long run effects of coordination

We begin by modeling the long run effects of coordination by themselves: i.e., we ignore short run synergies (setting $\delta = 0$) and consider the pure effect of coordinating the choices of the L elements of the two landscapes on the diversified firm's relative performance. In the absence of synergy, coordination between businesses has no immediate benefits, so it is unclear that a firm would ever choose to diversify[15]. But that is precisely where we want to begin—by isolating the effect of relatedness and complexity on the adaptation of diversified firms—before expanding our analysis to include the effect of synergies.

Figure 3 shows the effect of coordinating activities between businesses in the diversified firm. Specifically, it shows how the average performance of a diversified firm evolves over time (starting from a random point on the landscape) compared to the combined average performance of

[15] In fact, by setting $\delta = 0$ we are assuming that net synergies are zero. Given that coordination between businesses will give rise to bureaucratic costs (Williamson, 1985; Jones and Hill, 1988) even if they do not result in economies of scope, one might further consider the case where net synergies were negative, i.e., $\delta < 0$. We do not consider that case here, since we are only interested in the consequences of coordination for adaptation.

two focused firms over the same period. For illustrative purposes, we choose moderate values of relatedness ($R = 6$) and complexity ($K = 6$) for this figure, though we could draw similar graphs for any feasible value of R and K. Figure 3 shows that while the diversified firm starts off at the same performance level as its focused counterparts, its performance rapidly falls below that of the focused firms. Eventually, the performance of the focused firms as well as that of the diversified firm asymptotes, with the diversified firm's steady state performance being substantially below that of the focused firms, even though they both started at the same level. This persistent gap in the performance of the diversified firm relative to its focused counterparts is the result of its inability to fully adapt within businesses as it coordinates between businesses.

Insert Figures 3 and 4a about here

Figure 4a plots long run diversification advantage (i.e., the value of diversification advantage once both diversified and focused firms have arrived at a steady state) as a function of the level of relatedness (R) for low, moderate, and high levels of complexity ($K = 2, 6, 10$ respectively), as well as for the baseline case where there is no interdependence within the businesses ($K = 0$). Figure 4a shows that, absent short run synergies, the long run performance of diversified firms is always lower than that of their focused counterparts; in other words, the rigidity effects of coordinating between businesses dominate the cross-business learning effects.

Figure 4a also shows that, given complexity, this negative long run effect of coordination has a curvilinear relationship with relatedness. The disadvantage of diversified firms increases with relatedness but at a decreasing rate, with the relationship eventually reversing for high relatedness

with moderate to high complexity ($K = 6, 10$)[16]. Thus, moderately related diversifiers suffer long run negative consequences of coordinating between businesses that are almost as severe as those for highly related diversifiers, and potentially more severe if complexity is moderate to high. Note that this nonlinear relationship between long run effects and relatedness only arises on account of complexity within businesses; where such complexity is absent (the $K = 0$ case), diversification advantage more or less steadily decreases with relatedness. Moreover, the nonlinear effect of relatedness means that the effects of complexity essentially disappear at the highest levels of relatedness, with the $K = 2, K = 6$ and $K = 10$ lines rising up to meet the $K = 0$ line at $R = 12$.

To see what drives this overall diversification disadvantage, we break it down into its two constituent parts (as discussed earlier and shown in Figure 1): rigidity effects and cross-business learning effects. In order to separate the two, we start by allowing the diversified firm to achieve a steady state, then relax the constraints placed on it (by setting $L = 0$) and allow it to search further, eventually comparing the steady state performance of this first constrained then unconstrained firm to that of its never constrained (focused) counterparts. The intuition is that even if we stop coordinating between businesses, the benefits of their past learning persist—each business continues to use the best practices and routines it has discovered as a consequence of coordinating with the other—even if there is no further learning[17]. At the same time, stopping coordination unconstrains

[16] Online Appendix C plots the $K = 6$ and $K = 10$ lines along with their confidence intervals to confirm that the relationship is, in fact, U-shaped.

[17] To be clear, we are not suggesting that diversified firms will, or should, stop coordinating activities once they achieve a steady state. The procedure described here is simply a mechanical exercise to help us isolate cross-business learning effects from rigidity effects; one that only works so long as we assume that once the coordinated firm reaches a steady state all potential learning benefits have already accrued.

each business, allowing it to make autonomous choices, and thus overcome past rigidity. The relative advantage of the newly unconstrained firm thus provides a measure of the cross-business learning effects of coordination in the long run. Figure 4b graphs these cross-business learning effects as a function of relatedness for the same four values of K (0, 2, 6, and 10) used in Figure 4a.

Figure 4b shows that the benefits of cross-business learning generally increase with relatedness. This is fairly intuitive: the greater the similarity between two businesses, the greater the advantage from sharing knowledge between them. It also shows that in the absence of complexity ($K = 0$), there are no long run cross-business learning benefits of coordination between businesses. The intuition here is that so long as each activity is independent of the other, both focused and diversified firms will eventually arrive at the optimal choice for that activity, so the diversified firm has no long run advantage relative to focused firms[18]. The cross-business learning effects shown in Figure 4b arise because in the presence of complexity single business firms tend to get stuck at lower value local optima, which diversified firms avoid because coordination between businesses allows them to discover combinations of choices they would not otherwise have made[19].

Insert Figures 4b, 4c, and 5 about here

Figure 4c then plots the rigidity effects of coordination, which are calculated by subtracting the cross-border learning effect in Figure 4b from the net long run effect in Figure 4a. It shows that

[18] Cross-business learning may still help the diversified firm arrive at the optimal choice for each activity faster, even without complexity, but we are only focused on the long run consequences of coordination here.

[19] The extent of cross-business learning may also vary with the level of similarity between the structure of interdependence in the two businesses. While fully exploring that dimension is beyond our current scope, online Appendix D reports the results of a robustness check where we allow the structure (and extent) of interdependence to vary across the landscapes, and shows that our main findings are largely unaffected by this change.

rigidity effects initially increase with relatedness, but the rate of increase decreases as the two businesses grow more related, with the relationship reversing for high values of complexity and relatedness. As in Figure 4b, this nonlinearity is a result of complexity; in the absence of complexity the relationship between relatedness and rigidity is basically linear. The intuition here is that as relatedness increases, the two businesses become more similar, so the constraint imposed by greater coordination becomes less costly—what is good for one business is less harmful for the other.

Figure 5 plots the same long run (dis)advantage of diversified firms as figure 4a, only this time as a function of complexity (K) for low, moderate, and high levels of relatedness ($R = 2, 6, 10$ respectively). It shows that the long run effect of coordination has a nonlinear relationship with complexity as well. We see a clear pattern of a rapid fall in diversification advantage as we introduce even modest levels of complexity ($K = 2, 4$), followed by a relatively flat (and, in some cases, slightly increasing) slope as complexity increases further. This is consistent with what we had already seen in Figure 4a, where the line for $K = 2$ lay far below the line for $K = 0$ but the line for $K = 10$ was quite close to the line for $K = 2$. This nonlinear effect of complexity is important because it implies that negative consequences of coordination between businesses for adaptation do not only matter for extremely complex businesses, where all the different activities within a business are tightly tied to each other. Even in cases where every activity in the business is only linked to one or two other activities, such within-business complexity will rapidly amplify the constraints of any coordination between businesses, compromising the diversified firm's ability to successfully adapt. The basic intuition for this nonlinear effect is that every additional activity coordinated between businesses

constrains several other choices in both businesses. So, for instance, with a complexity of $K = 3$ even coordinating two activities between businesses ($L = 2$) means that the number of constrained choices may be as high as eight. This multiplier effect means that even at relatively modest levels of both R and K, most of the firm's choices are already constrained, so further increases in complexity have little additional negative effect on adaptation in diversified firms.

The effects of synergy

While our analyses thus far examine the long run consequences of coordination between businesses as a function of relatedness and complexity, it is clear that this is only part of what distinguishes diversified firms from their focused counterparts. To fully assess the performance consequences of coordination, we need to factor in not only these long run consequences, but also the short run synergies (net of bureaucratic costs) that the diversified firm enjoys as a result of coordinating activities between businesses.

Figure 6a shows the effect of considering synergies between businesses; specifically, it revisits the results in Figure 3, comparing the average performance of a diversified firm to that of its focused counterparts over time, only this time allowing for synergies between businesses (specifically, setting $\delta = \frac{1}{N}$). Figure 6b then plots the performance advantage of the diversified firm (corresponding to Figure 6a) over time. As the figures show, the inclusion of synergies means that the diversified firm initially enjoys a performance advantage. This is because it is immediately able to enjoy the benefits of synergy resulting from the sharing of capabilities between its businesses. As time progresses however, the very coordination between businesses that enabled it to realize those

synergies also makes it harder for each business to adapt, so the diversifier's initial advantage relative to the focused firms deteriorates, eventually (in this case) turning negative in the long run. Thus, the diversified firm benefits from synergies between businesses in the short run but these benefits may be (partly or wholly) undone by the long run negative effects of coordination between businesses. Thus, given complexity, the promise of synergies may drive firms to coordinate activities between businesses in a way that leads to lower (and potentially negative) long run performance.

Insert Figures 6a, 6b, 7a, 7b, 7c, and 7d about here

Figures 7a, 7b, and 7c explore this point further, showing how the long term diversification advantage (as a function of R and K) changes as we increase the level of synergy (to $\delta = \frac{1}{2N}, \frac{1}{N}, \frac{3}{2N}$ respectively). As these figures make clear, while the addition of synergy increases long run diversification advantage, especially for high values of relatedness (as we would expect), it does not fundamentally alter the nonlinear relationship between relatedness and diversification advantage. We still see a nonlinear relationship between the long run advantage of the diversified firm and relatedness, with the diversified firm's advantage falling (and potentially turning negative) as relatedness initially increases, but then starting to rise as we approach high levels of relatedness. Thus, in the presence of complexity, moderate levels of relatedness continue to result in the weakest advantage for the diversified firm in the long run, precisely because the negative long run effects of coordination in this case dominate the moderate synergies realized. Of course, with sufficiently high levels of synergy even a firm diversified into a moderately related business may realize a long run diversification advantage, but even in that case we would continue to see a nonlinear effect, with the

increase in diversification advantage as we go from low to moderate relatedness being substantially lower than the corresponding increase when moving from moderate to high relatedness. Figure 7d shows such a case, with synergies high enough that even at moderate levels of relatedness the diversified firm is not at a long run disadvantage. Note that this case requires setting $\delta = \frac{5}{2N}$, implying that the firm's capabilities are over 20% more productive when shared between businesses, even after accounting for bureaucratic costs.

Figures 7a to 7d also show that as synergies rise, the long run performance advantage of highly related diversifiers rises steadily—as we would expect—so that not only do highly related diversifiers outperform their focused counterparts, but, other things being equal, the diversified firm's performance is highest with high relatedness, as it was not in Figure 4a. The intuition here is that as synergies increase, the benefits of being in highly related businesses come to dominate the negative effects of coordination on adaptation, even in the long run (especially in cases with high complexity). Finally, Figures 7a to 7d also continue to show a nonlinear effect of complexity on diversification advantage, with the gap between the $K = 0$ line and the $K = 2$ line being substantially greater than the gap between the $K = 2$ and $K = 10$ lines throughout.

Optimal coordination

The results in Figures 7a through 7d assume that the diversified firm always chooses to coordinate all activities that are even slightly related across businesses, consistent with prior work that has generally associated higher relatedness with greater coordination (Jones and Hill, 1988). That assumption makes sense so long as we consider only on the short run effects of coordination,

since in the short run the diversified firm is always better off coordinating any activities that result in net positive synergies, i.e., setting $L = R$. Once we recognize that such coordination may have negative long run consequences, however, it becomes important to consider that the decision to coordinate activities between businesses—even those that are potentially related—is a choice (Zhou, 2011). So, for instance, a firm could choose to develop a different brand for each of its businesses, even if both businesses sold to the same segment of customers, and had an identical value proposition. In this section, we therefore consider what would happen if the firm were sufficiently foresighted to recognize that coordinating its choices across businesses would constrain it from adapting in the long run, and therefore chose the optimal level of coordination between businesses ex ante[20]. Note that we continue to assume that firms may find it challenging to dynamically change their level of coordination given adjustment costs (Argyres et al., 2015; Argyres et al., 2018), so that L, once chosen, does not change over time.

In order to assess the optimal level of coordination, we simulate and derive the long run diversification advantage for all values of L for given values of R, K, and δ. Figure 8 shows the result of this analysis for one set of values: $R = 8, K = 10, \delta = \frac{3}{2N}$. We then define L^* as the value of L where the firm's long run diversification advantage is highest: in the case shown in Figure 8 that would be $L^* = 4$. Repeating this exercise for every value of R, K, and δ gives us the optimal coordination level that the diversified firm should choose, for any given set of parameter values.

[20] Of course, being able to know the optimal level of coordination between businesses ex ante would require an almost heroic level of strategic foresight, especially when coupled with the fairly myopic version of local search assumed in our NK model. Nevertheless, examining the optimal coordination case is interesting because it allows us to consider the best the diversified firm could have done by endogenously choosing L.

Clearly, $L^* = 0$ if $\delta = 0$; absent synergies, the diversified firm should never coordinate any activities between businesses, as evidenced by the uniformly negative performance of the diversified firm in Figure 4a earlier. Moreover, given that, by assumption, the firm can only realize synergies by coordinating between similar activities, $L^* \leq R$, i.e., it never makes sense for the diversified firm to coordinate entirely dissimilar activities[21].

Insert Figures 8, 9a, 9b, and 9c about here

Figures 9a through 9c show the values of L^*as a function of R and K, for levels of synergy corresponding to those in Figures 7a through 7c respectively. They show that, in general, $L^* < R$, i.e., the diversified firm is better off coordinating only some of the similar activities between its businesses. In the extreme, they show that with low or even medium synergies $L^* = 0$ with low to moderate relatedness, meaning that in such cases diversification may be a suboptimal choice, with the two businesses being better off if left to adapt autonomously (Williamson, 1991) despite the potential for short run synergies between them[22]. Even when diversification is potentially valuable, moreover, the optimal number of activities to coordinate lies far below the number of potentially related activities between the two businesses, with this gap being highest for moderate levels of relatedness, and increasing at a decreasing rate with complexity. Only in the case of very high relatedness and complexity with high synergies is the benefit from synergies great enough (and the

[21] In addition, since by design activities are organized in decreasing order of similarity (and therefore synergy), in choosing L^* the firm is not only choosing the optimal level of coordination, it is also choosing the activities that will yield the highest level of short run synergies given that level of coordination.

[22] In principle, such autonomy could be achieved by a single firm diversifying but not coordinating at all across businesses, though such an arrangement may be challenging, given the impossibility of selective intervention (Williamson, 1985); put differently, diversification only makes sense if there is at least some coordination between businesses (Hart and Holmstrom, 2010).

long run effects sufficiently small) to make it worthwhile for the diversified firm to coordinate all related activities between businesses.

The results in Figures 9a through 9c suggest that diversified firms may be susceptible to overcoordination between businesses. While conventional wisdom might suggest that the firm look for and realize every possible synergy between two businesses—and doing so might prove beneficial in the short run—the long run cost of doing so may be an inability to adapt in each business that will impose severe costs on the diversified firm, especially if complexity within businesses is high and relatedness between businesses is moderate. Instead, the diversified firm may be better off exploiting only a handful of the most promising synergies between the two businesses, while leaving several smaller synergies untapped, so as to retain the flexibility necessary to adapt within businesses.

This overcoordination problem is interesting because it highlights a relatively unexplored dimension of firm diversification. As previously mentioned, much of the prior research on coordination costs and their impact on diversification has focused on the *breadth* of a firm's diversification—asking how many businesses a firm should enter (Jones and Hill, 1988) and how that answer changes depending on the relatedness of the businesses in question (Nayyar, 1992; Zhou, 2011). In contrast, our analysis emphasizes how much a diversified firm should coordinate between any two businesses, thus focusing attention on the *depth* of a firm's diversification. The findings in Figures 9a through 9c thus suggest the existence of a problem of overcoordination that is distinct from, but parallel to, the problem of overdiversification frequently discussed in the literature (Markides, 1992; 1995) and offers an alternate but complementary reason why diversified firms may

sometimes find themselves at a performance disadvantage relative to focused firms (Miller, 2004).

Insert Figures 10a, 10b, and 10c about here

To further examine the performance of diversified firms, Figures 10a through 10c plot the long run performance advantage of the diversified firm, at the optimal level of coordination (L^*) as shown in Figures 9a through 9c respectively. In other words, they plot the maximum long run performance advantage[23] the diversified firm could hope to achieve for the given values of relatedness (R), complexity (K), and synergy (δ), assuming it made the optimal ex ante choice on how much to coordinate between businesses. These figures show that, once the overcoordination problem is resolved, diversification advantage unilaterally increases with relatedness, but in a nonlinear way. Specifically, while diversification into highly related businesses almost always results in a performance advantage, diversification into moderately related businesses is not especially advantageous, being generally comparable to diversification into largely unrelated businesses. The intuition behind this result is that the long run negative effects of coordination between businesses in moderately related diversifiers mean that they are generally better off coordinating only a few of the many activities they could potentially coordinate (L^* is low), if they coordinate at all, so that they essentially act like unrelated diversifiers, and achieve similar performance levels.

The results in Figures 10a through 10c—coupled with those in Figures 9a through 9c—suggest that not all synergies are worth tapping, especially for businesses with high complexity. In many cases, firms in complex businesses may be better off not diversifying into unrelated or

[23] Note that the diversification advantage is always positive at L^*; if that were not the case, the firm would always have the option of not coordinating at all and achieving a performance identical to that of its focused peers.

moderately related businesses at all; while doing so may offer some short run synergies, the long run negative impact of coordination on adaptation means that both businesses are better off staying autonomous. Even where diversification is valuable, these results, along with those in Figures 7a through 7c, offer a strong case in favor of conglomerate diversification, i.e., diversification where the firm leaves its businesses largely independent, coordinating only a few activities between them. Not only are all but the most strongly related diversifiers better off in the long run choosing a conglomerate structure where they limit coordination to only a few key activities, but failing to make that coordination choice correctly may have far more negative long term consequences for moderately related diversifiers than for largely unrelated diversifiers. Of course, firms are still better off diversifying into highly related businesses, but such businesses (where the majority of two businesses activities share similarities with each other) may not always be available.

Conclusion and discussion

Our study sheds new light on the consequences of coordination between businesses for the long run performance of diversified firms. Using a simulation based approach, we show that the coordination of activities between businesses in diversified firms limits adaptation within businesses. While coordination enables diversified firms to realize synergies (net of bureaucratic costs), giving them an advantage relative to single business firms in the short run, this advantage may decline in the long run as the individual businesses fail to keep up with their focused counterparts. Moreover, this effect is jointly moderated by complexity within and relatedness between businesses. In particular, this negative effect is highest for moderately related diversifiers with moderate to high complexity, so that firms diversifying into moderately related businesses in pursuit of short run

synergies may find themselves at a disadvantage compared to their single business counterparts in the long run. Given complexity within its businesses, a firm may therefore be better off limiting the extent of coordination between businesses, foregoing marginal synergies in order to preserve long run flexibility. Moreover, these negative long run effects of coordination mean that, even with optimal levels of coordination between businesses, the long run performance advantage of diversified firms may increase at an increasing rate with relatedness, with moderately related diversifiers doing just marginally better than unrelated diversifiers and substantially worse than highly related diversifiers.

The results of our simulation thus extend research on diversification as a source of rigidity (Rawley, 2010; Natividad and Rawley, 2016)—as well as the costs of coordination in diversified firms more generally (Jones and Hill, 1988; Zhou, 2011)—by highlighting the role of complexity within businesses in limiting diversified firms' ability to adapt (Burgelman et al., 2018). On one hand, most of the findings from our analysis are driven by the presence of complexity; where there is no interdependence between activities within businesses ($K = 0$), we do not see any of the nonlinear effects our study highlights. On the other, we also show that our nonlinear effects arise with fairly modest levels of complexity ($K = 2, 4$), such as we would expect to see in many firms, and are not limited to highly complex businesses. As such, our simulation results emphasize the importance of keeping within-business complexity in mind when considering the costs of coordination and the limits to firm scope. In doing so, our study serves as a potential bridge between work in corporate strategy that has studied the effects of interdependence between businesses (Rawley, 2010; Zhou, 2011) and work on search and adaptation that has highlighted the role of complexity in the context

of a single business (Levinthal, 1997; Gavetti and Levinthal, 2000; Ethiraj and Levinthal, 2004).

By examining the adaptive consequences of coordination between businesses, our study also complements and extends recent work that has highlighted the role of organizational scope choices as a source of rigidity (Sorenson, 2003; Shaver, 2006; Gartenberg, 2014; de Figueiredo et al., 2015; Claussen et al., 2015). We contribute to this work by stressing the gap between a diversified firm's short run and long run performance, showing that, in the presence of complexity, the same choices that maximize synergies in the short run may also compromise long run performance by limiting the firm's ability to adapt. As such we offer an additional potential explanation for why diversified firms may sometimes operate at a discount to focused firms: one that does not require either self-interested behavior on the part of managers (Lang and Stulz, 1994) or adverse selection of underperforming firms into diversification (Miller, 2004; Villalonga, 2004). The results from our model are thus also consistent with prior empirical work showing that diversification is associated with less innovation (Hoskisson and Hitt, 1988; Hoskisson and Johnson, 1992) and that diversification is more advantageous when diversified firms sustain their innovative efforts (Miller, 2006). Our study also shows that these negative effects of coordination do not monotonically increase with interdependence between businesses, as prior work might suggest (Rawley, 2010; Zhou, 2011; Natividad and Rawley, 2016). In particular, we show that—consistent with potential for within-firm replication stressed in evolutionary theory (Nelson and Winter, 1982; Rivkin, 2001; Zollo and Winter, 2002)—an important source of value in diversified firms is the ability to transfer knowledge of successful adaptations in one business to the other (Miller et al., 2007; Williams, 2007; Kim and Anand, 2018), and that these cross-business learning benefits may at least partially offset

the rigidity effects of coordination between businesses.

Our study also contributes to the study of corporate diversification more generally. While the focus of this work has often been on the breadth of a firm's diversification—examining how many businesses firms enter and the consequences of doing so (Jones and Hill, 1988; Palich et al., 2000; Zhou, 2011)—we draw attention to the depth of a firm's diversification, i.e., how much it coordinates between any two businesses. While prior work has thus highlighted the problem of excessive diversification (Markides, 1992; 1995), arguing that diversified firms underperform their focused counterparts because they compete in too many businesses or choose the wrong businesses, we suggest that diversified firms may also be susceptible to a problem of overcoordination. Our findings suggest that choosing a level of internal coordination such that the marginal bureaucratic costs just offset the marginal economies of scope in the short run (Jones and Hill, 1988) may prove suboptimal in the long run, and that diversified firms may therefore benefit from limiting the extent of coordination between their businesses, foregoing some short run synergies in order to retain long run flexibility[24]. By emphasizing that the extent of coordination between businesses is a choice (Zhou, 2011), our study also suggests that firms may strategically trade-off breadth and depth, strategically choosing to realize fewer synergies between businesses as they widen their portfolio.

As such, our study offers a novel rationale for conglomerate diversification, suggesting that firms may choose to diversify across relatively unrelated businesses (or, equivalently, treat the moderately related businesses they enter as though they were largely unrelated, coordinating only

[24] Our study thus also relates to work on post-merger integration and the advantages of leaving acquired targets independent (Puranam, Singh, and Zollo, 2006; Puranam and Srikanth, 2007; Puranam, Singh, and Chaudhuri, 2009)

one or two key activities between them) because doing so allows them to be more flexible within businesses. It thus formalizes and extends early work which showed that the M-form structure is most valuable for unrelated diversifiers (Hoskisson, 1987; Hoskisson, Harrison, and Dubofsky, 1991) suggesting that the virtue of such a structure may lie in enabling the kind of limited coordination that is optimal in the long run. Our study also speaks to the question of whether firms should diversify at all, suggesting that even where there is some short term potential to benefit from economies of scope between moderately related businesses, despite the costs of information transfer and sharing involved (Jones and Hill, 1988; Zhou, 2011), firms in complex businesses may be better off in the long run by not diversifying[25]. Our findings thus re-emphasize the fundamental tension between coordination and adaptation within organizational hierarchies (Williamson, 1991), and extend recent work on the effect of within business complexity on organizational scope and structure choices (Weigelt and Miller, 2013; Brahm and Tarzijan, 2016).

In emphasizing the idea of optimal coordination, our study also speaks to work on dynamic capabilities (Helfat et al., 2007; Teece, 2007; Helfat and Winter, 2011). As our simulation results show, choosing the right level of coordination between businesses has substantial performance implications, and the capability to coordinate optimally between businesses may thus be an important dynamic capability for diversified firms. Further, while our model does not consider the potential for firms to dynamically adjust their level of coordination, an implication of the trade-off

[25] While we consistently treat the complexity of the firm's business as exogenous—consistent with both the NK modeling literature (Levinthal, 1997) and empirical work examining the effect of interdependence within businesses on performance (Lenox et al., 2010; Lee and Alnahedh, 2016)—a parallel implication of our findings is that firms seeking to tap into synergies between moderately related businesses may be better off choosing lower levels of complexity.

between short run synergies and long run flexibility we highlight is that an important capability for diversified firms is the ability to constantly adjust their internal structure to orchestrate their capability choices across businesses (Helfat and Raubitschek, 2000; 2018; Helfat and Peteraf, 2003), and realize untapped synergies while limiting disruptions and remaining flexible (Karim, 2006; Karim and Kaul, 2015). In fact, our findings for the cross-business learning effect suggest that, in the presence of complexity, businesses may not only learn best practices on specific activities from each other, they may also learn how best to organize the various activities within a businesses in order to best manage the interdependencies between them.

Though not the primary focus of our study, our findings also have implications for the growing literature on inter-temporal economies of scope (Helfat and Eisenhardt, 2004; Levinthal and Wu, 2010) and the potential for diversified firms to redeploy their resources across businesses over time (Kaul, 2012; Wu, 2013; Sakhartov and Folta, 2014; 2015; Vidal and Mitchell, 2015; Folta, Helfat, and Karim, 2016). While this work emphasizes the benefits that firms can realize by redeploying resources from one business to the other (Helfat and Eisenhardt, 2004; Folta et al., 2016; Levinthal, 2017), relatively less attention has been paid to the costs of maintaining this option to redeploy (Sakhartov and Folta, 2015; Levinthal, 2017). To the extent that maintaining the redeployability of a resource (Anand, Kim, and Lu, 2016; Folta et al., 2016) means ensuring that it remains compatible with its potential use in a future business it may constrain the firm's ability to adapt that resource to its current use; consistent with this, empirical work has shown that diversifying firms have less specialized capabilities ex ante (Miller, 2004). Thus the need to maintain resource compatibility between current and future businesses may produce negative effects similar

to those of coordinating resources choices between current businesses. Future work could extend our simulation model by considering redeployment into a new market, comparing the performance of redeployers to that of diversifying or de novo firms (Agarwal et al., 2004; Ganco and Agarwal, 2009; Qian et al., 2012; Kapoor and Furr, 2015; Moeen and Agarwal, 2017).

Future work could also build on our simulation model in other ways. By extending the familiar NK model to a diversified firm setting, our study provides the foundation for a range of additional analyses of how such firms adapt. Thus, future work could build on our model to examine questions of organizational structure and design (Rivkin and Siggelkow, 2003; Siggelkow and Rivkin, 2005; 2006; Weigelt and Miller, 2013; Kim and Anand, 2018), examining, for instance, how decision rights over the various related and unrelated activities are best assigned, or how different levels of centralization or decentralization (Alonso et al., 2008; 2015) and incentives for competition or cooperation (Hill et al., 1992) impact the speed of adaptation in diversified firms. Or it could study how the effects of coordination on adaptation we document change if we allow the two businesses to vary in either the level of their complexity (i.e., assume a different K for each landscape) or its structure (Rivkin and Siggelkow, 2007).

Finally, future work could also study the implications of our findings empirically. While the mapping between a simulation model and the real world is necessarily imperfect, our study does offer several testable propositions. It suggests, for instance, that the performance advantage of diversified firms may attenuate with age—with the both the profitability and the odds of survival of diversified firms relative to their focused counterparts declining over time—and that this attenuation

may be more pronounced for moderately related diversifiers than for highly related or unrelated diversifiers. It also suggests that firms that adopt a more conglomerate like structure may outperform others when diversifying into unrelated or moderately related businesses, and, more specifically, that such conglomerate structures should be especially valuable for innovation in each business. Future researchers could test these predictions empirically.

To conclude, we use a simulation based approach to study adaptation in diversified firms, arguing that coordination between businesses to realize synergies may limit adaptation within businesses. We find that these negative long run effects of coordination increase with both complexity within businesses and relatedness between businesses, but in a nonlinear way, being highest in the presence of moderate relatedness and complexity. The presence of these negative long run effects of coordination not only means that the long run performance advantage of diversified firms has a curvilinear relationship with relatedness, it also means that firms may be better off limiting the level of coordination between businesses so at maintain long run flexibility. Our study thus points to a potential overcoordination problem in diversified firms, while also offering a novel rationale for conglomerate diversification.

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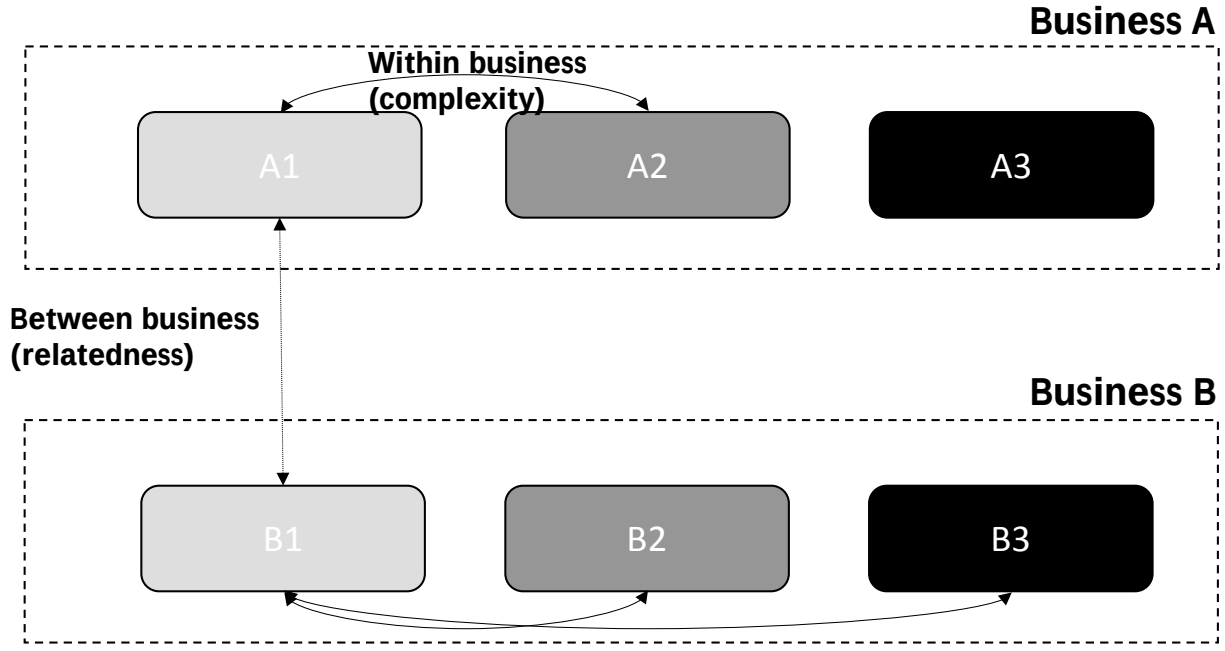
	Short Run	Long Run
Benefits	Economies of Scope	Cross-business Learning
Costs	Bureaucratic Costs	Rigidity

Figure 1 Effects of Coordination Between Businesses in Diversified Firms



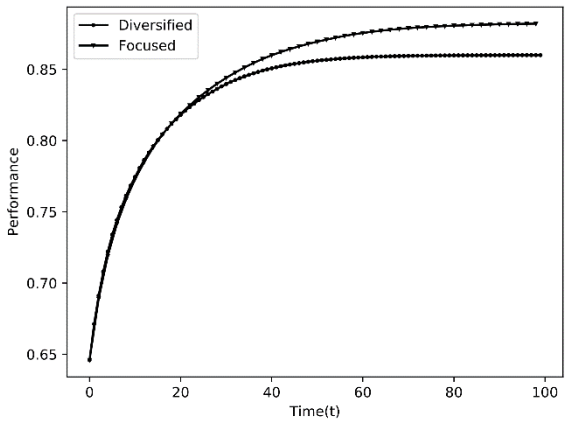
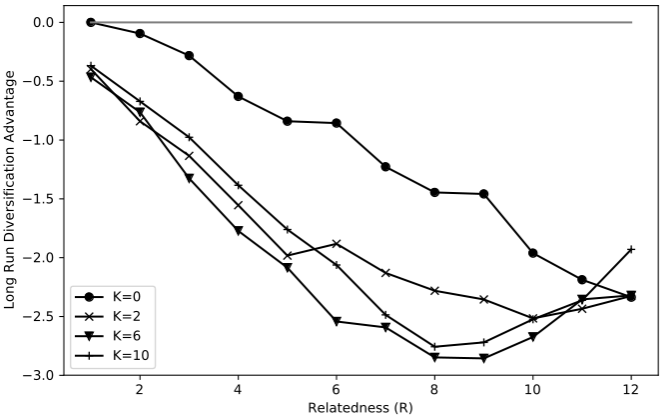


Figure 2 Interdependence within and between businesses

Figure 3 Diversified vs. focused firm performance over time (without synergy)



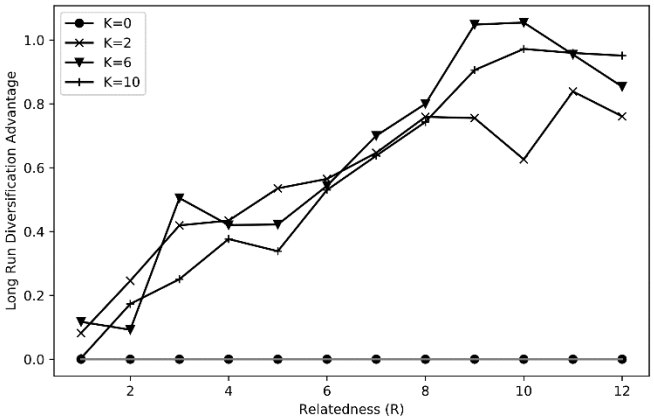
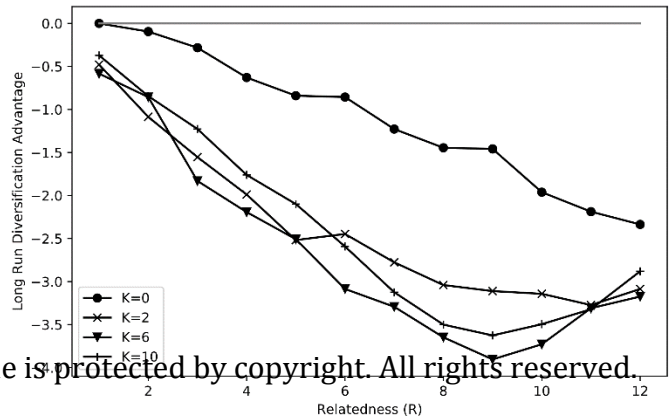
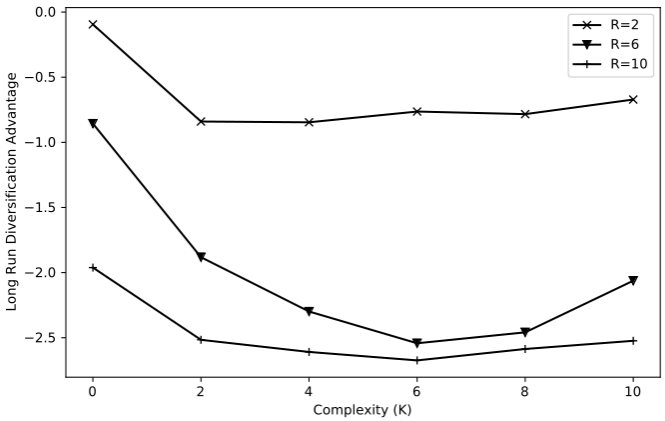


Figure 4a Long run effects of coordination between businesses

Figure 4b Cross-business learning benefits

Figure 4c Rigidity effect





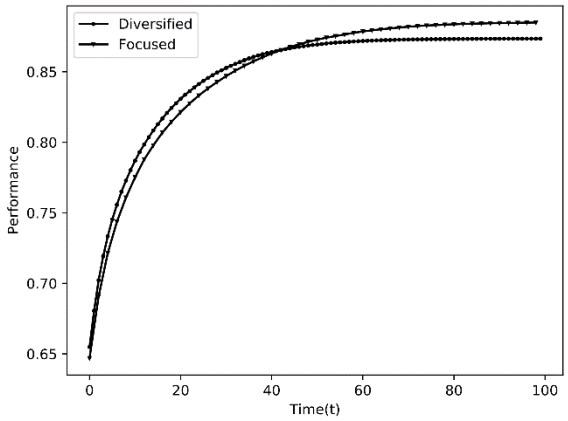


Figure 5 Long run effects of coordination as a function of complexity

Figure 6a Diversified vs. focused firm performance (with synergy)

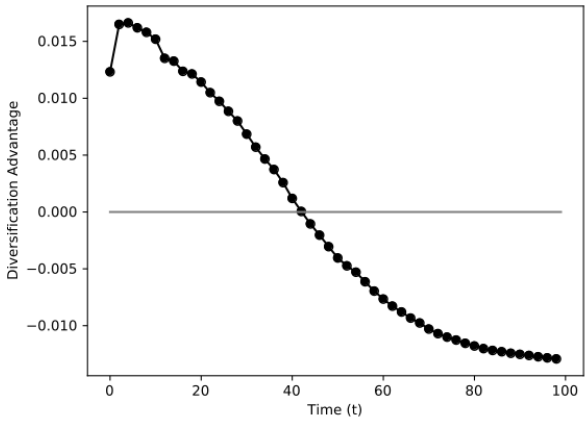


Figure 6b Diversification advantage (with synergy) over time

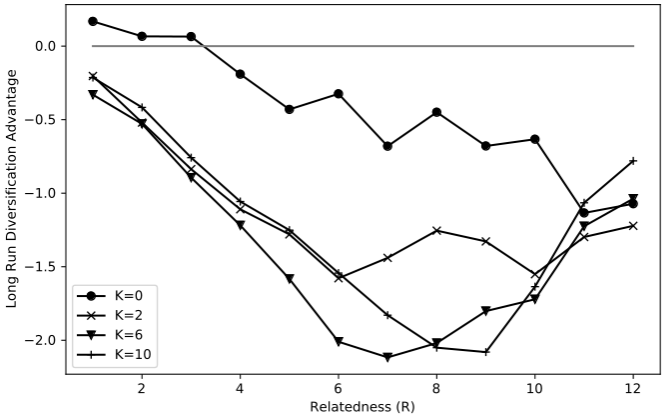
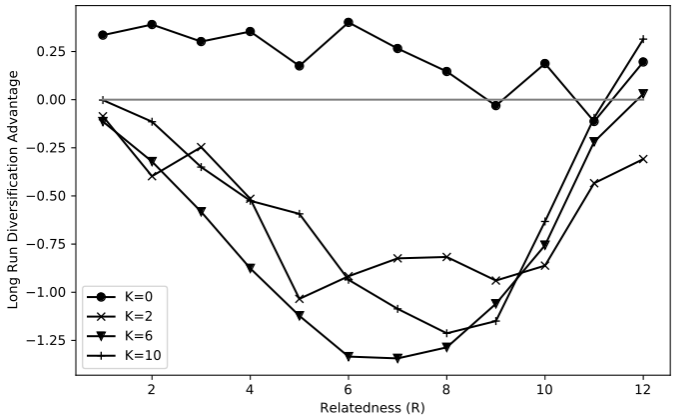


Figure 7a Long run diversification advantage with low synergy ($\boldsymbol{\delta = \frac{1}{2N}}$)



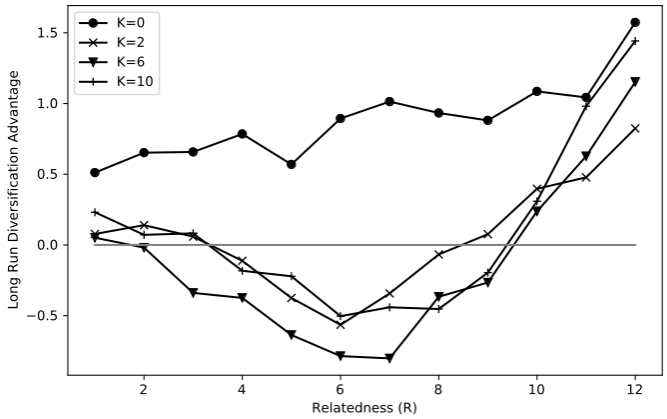


Figure 7b Long run diversification advantage with moderate synergy ($\boldsymbol{\delta = \frac{1}{N}}$)

Figure 7c Long run diversification advantage with high synergy ($\boldsymbol{\delta = \frac{3}{2N}}$)

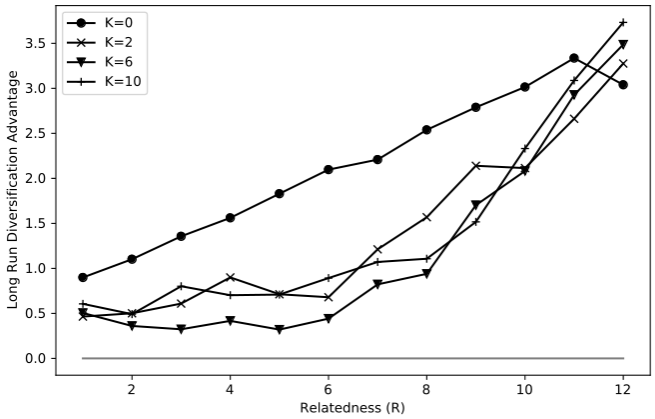


Figure 7d Long run diversification advantage with extremely high synergy ($\delta = \frac{5}{2N}$)

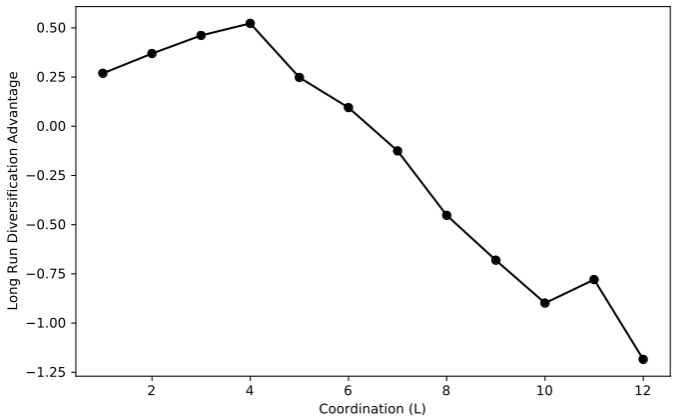


Figure 8 Effect of changing coordination levels

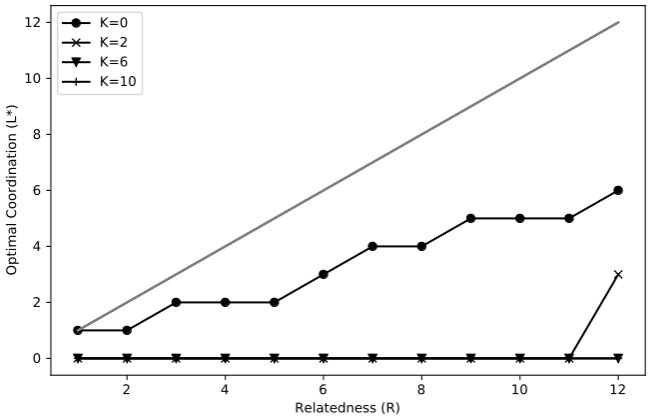


Figure 9a Optimal coordination with low synergy

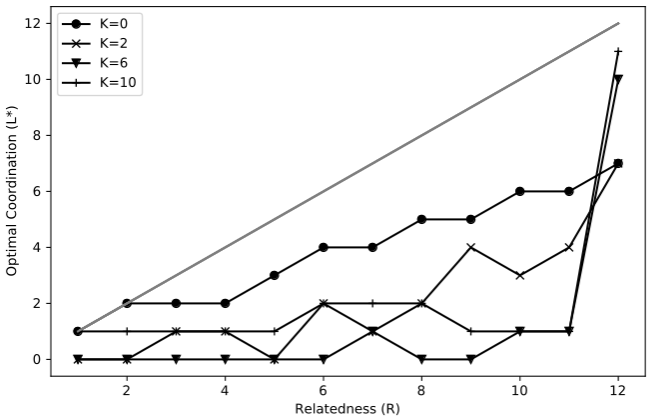


Figure 9b Optimal coordination with moderate synergy

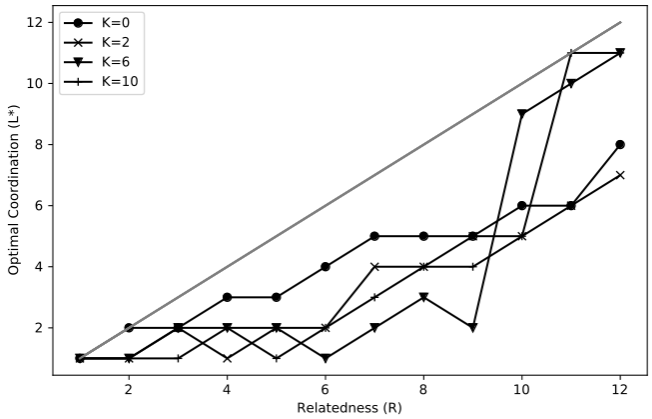


Figure 9c Optimal coordination with high synergy

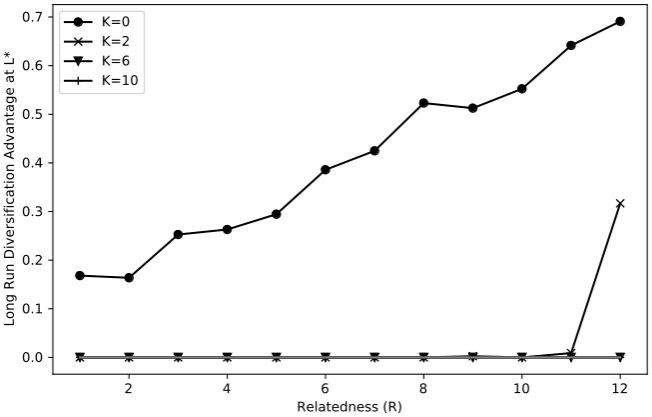


Figure 10a Optimal long run advantage with low synergy

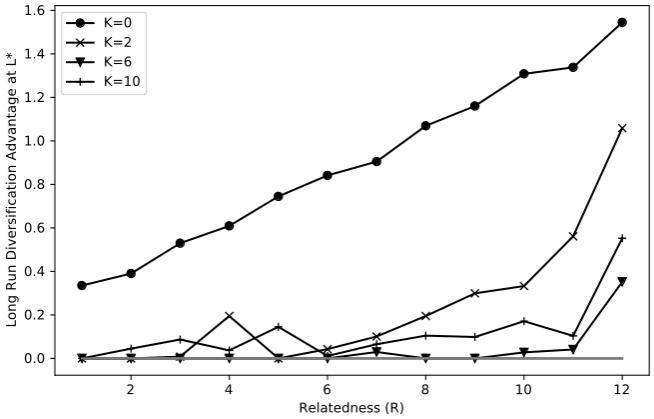


Figure 10b Optimal long run advantage with moderate synergy

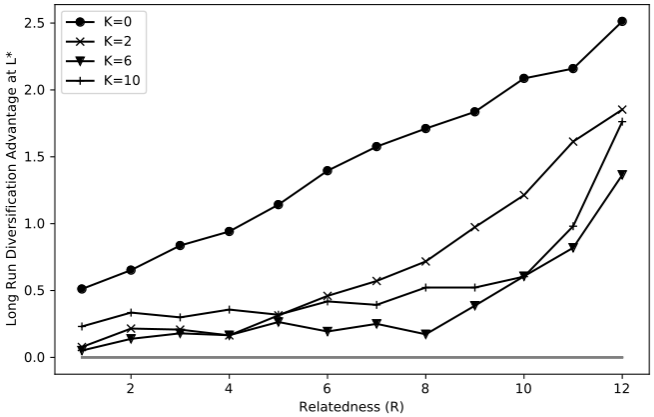


Figure 10c Optimal long run advantage with high synergy

ADAPTATION ACROSS MULTIPLE LANDSCAPES: RELATEDNESS, COMPLEXITY, AND THE LONG RUN EFFECTS OF COORDINATION IN DIVERSIFIED FIRMS

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