Appendix S1: Mid-Term Liability of Focus on the Core

In our theorizing, we claim that the mid-term liability of focusing a firm's search efforts on its core choices emerges because changes to the core are likely to become increasingly difficult, i.e. they become more and more likely to be unsuccessful. We further argue that in non-hierarchical or near-hierarchical systems this higher risk cannot be compensated by the higher performance impact of core changes and, as a result, in the mid-term, a focus on the periphery outperforms a focus on the core. This explanation is different from, for example, Levinthal and Posen's (2007) theory that attributes mid-term performance differences of search strategies to coordination problems in solving interdependent problems.

In order to further test the robustness of our arguments, we run a series of additional experiments constructed to identify whether in the absence of important elements of our theory, we still observe a mid-term liability (given the boundary conditions we already discussed in the main body of the paper). Such a result would falsify our theoretical claims about the mechanisms underlying the mid-term liability of a focus on the core.

In our first falsification test, we modify the local search mechanism so that local search is always successful, i.e., in each period, the agent explores all one-bit-mutations of the status quo until an improvement is found (or there is convergence to a local or global peak). Put differently, with such a search process, whether an organization's focuses on core or peripheral choices does not affect the risk of failure – the risk that search is unsuccessful is 0% in both cases (as long as the organization has not yet converged to a peak). As predicted by our theory, with this modified local search mechanism, the mid-term liability disappears. Instead, a focus on the core outperforms a focus on the periphery for all time horizons since every change to the core exhibits a relatively larger performance impact compared to a change to the periphery.

In second set of tests, we examine whether the mid-term liability decreases as differences in the extent of complexity decrease. The mid-term liability decreases to zero as differences in complexity approach zero.

In the second sub-section, we provide some additional supporting evidence for our theory. Most importantly, since this mid-term liability emerges even if core and periphery are completely independent, our problem becomes one of solving two independent problems of different levels of complexity. Thus, if we can understand how complexity affects the success and performance impact of local search processes, we can also understand why a mid-term liability emerges in our setup. The impact of complexity on local search has already been studied extensively by Kauffman (1993). We therefore report his findings on this question, in particular how complexity affects the success likelihood and risk of local search and replicate his analyses on the temporal dynamics of the success likelihood.

Falsification Tests

Falsification Test 1: Differences in Risk

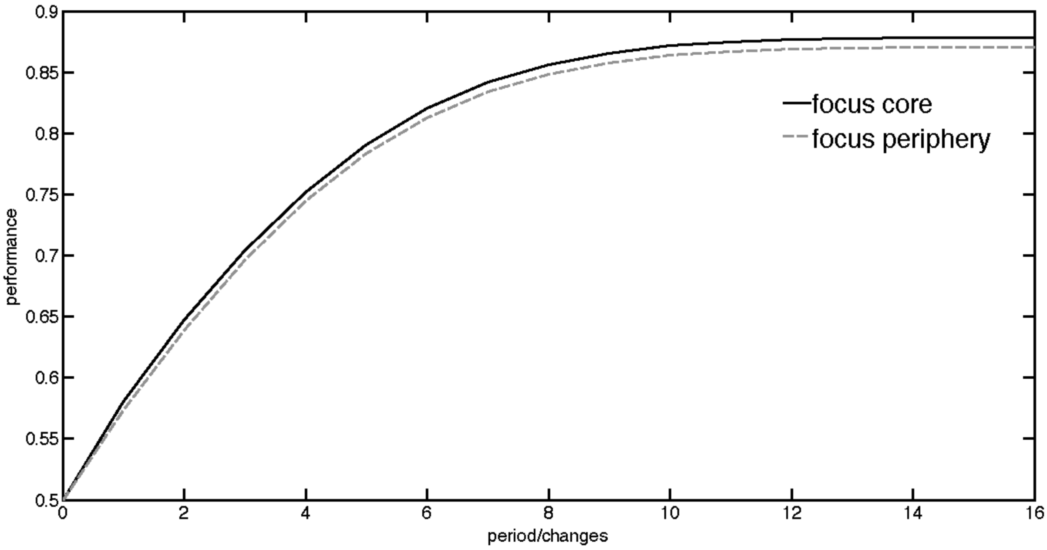
Since we argue that the primary driver behind the mid-term liability are differences in risk of failing to improve performance, we verify that this liability disappears if local search is exhaustive. With exhaustive search, in each period, the firm searches locally until it finds an improvement over the status quo. With this modified search rule, there are no longer differences in risk while the differences in performance impact between core and peripheral remain.

To implement this experiment we modify the hill climbing search algorithm such that as long as the agent has not yet converged to a peak, it continues to search among the N choices until it has found a choice that improves performance. Thus, for both a search along core and peripheral choices, the risk of failure is 0% in each period.[1]

Focus still matters: If the focus is on core choices, core choices still have the same higher probability of being searched than peripheral choices and performance differences for core and peripheral choices continue to be different.

In Figure S1-1, we plot the performance (y-axis) of a focus on the core (black solid line) and a focus on the periphery (gray dashed line) as a function of time (x-axis). Obviously, with our modified local search mechanism, agents converge much faster and we restrict our observation to the first 16 periods.

Figure S1-1 Exhaustive Local Search (K_C=6, K_P=2, and K_{CP}=K_{PC}=1).



If we still observed a mid-term liability with this modified local search mechanism, it would suggest that it is caused by something other the differences in risk for searches along the core and periphery. However in the absence of differences in risk, the mid-term liability disappears and a focus on the core is always better than a focus on the periphery, regardless of the time horizon.

Falsification Test 2: Differences in Risk and Performance Impact

As a further falsification test of our mechanism, we tested whether we observe the mid-term liability even if core and periphery exhibit the same level of complexity. Our theory suggests that if core and periphery exhibits identical levels of complexity, differences in risks (as well as differences in performance impact) should disappear and, as a result, the mid-term liability also should disappear. If we observed a mid-term liability despite identical risks and performance impacts, it would suggest that we were missing important elements in our theory.

In Figure S1-2, we plot the performance differences between a focus on the core and periphery if both core and periphery exhibit high (K_C=K_P=5, dotted line) and low (K_C=K_P=1, dashed line). We also added our baseline results as a benchmark.

If there are no differences in complexity between core and periphery, the mid-term liability disappears, as our theory would predict.[2] This finding holds for both low and high complexity.

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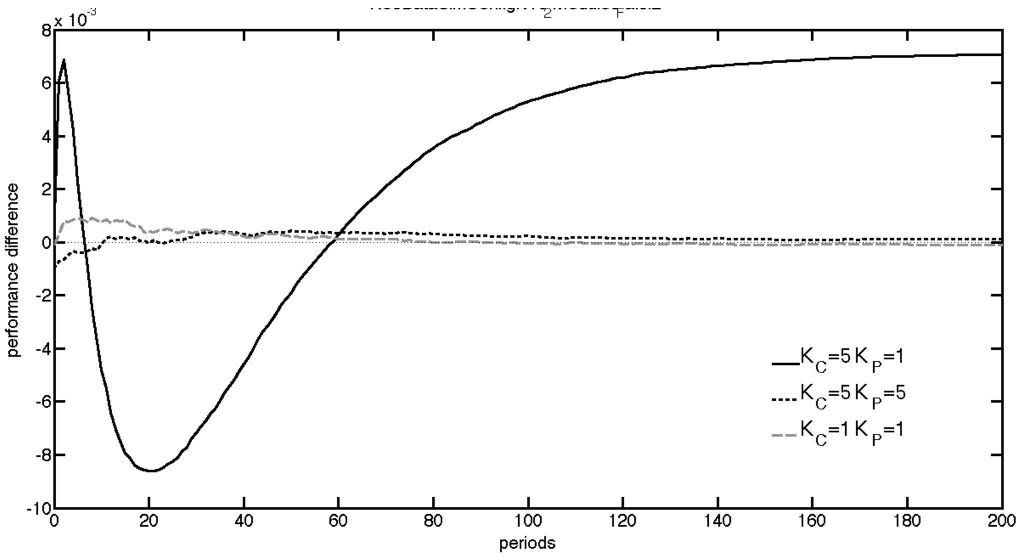
[1] Such a local search mechanism is similar to, for example, Rivkin and Siggelkow's (2003) modified local search mechanism that also explores several one-bit mutations at a time. It is different in that we assume that agents stop their search among one-bit variants once they find a variant that improves performance over the status quo. In other words, our version does not necessarily pick the best among all N possible variants ("steepest path"). Thus, we are not introducing a further assumption about the agents' behavior.

Figure S1-2 Differences in Complexity between Core and Periphery (with K_{CP}=K_{PC}=1)



Falsification Test 3: Differences in Core and Periphery Complexity

In a next set of falsification tests, we further explored the effect of subsystem complexity on the emergence of the mid-term liability. In Table S2-1 (see Appendix S2), we report the mid-term performance difference for a focus on the core and periphery for different levels of complexity of the core (rows) and periphery (columns). We also compute the significance of these differences. We highlighted (gray background) those configurations for which we did not observe the expected significant negative effect.

Only if the core exhibits low levels of complexity, do we not observe any mid-term liability. We assume that there are also interactions between core and periphery (K_{CP}= K_{PC} =1), i.e., core and periphery are not entirely independent of each other. If the complexity of the core is low, these interactions between core and periphery dominate the results. In the absence of these interactions, we would observe a mid-term liability for all combinations of complexity.

Supporting Tests and Evidence

Kauffman's (1993) analyses of the performance of local search algorithms in performance landscapes of different levels of complexity provide some further evidence supporting our claim that the mid-term liability is driven by different risk-return characteristics of search along core and peripheral choices.

Recall from our first falsification test above that a mid-term liability emerges even if core and periphery are entirely independent.[3] In the absence of any interdependence between core and periphery, the solutions to these two sub-problems are also entirely independent and searching one sub-problem does not interfere with the search of the other sub-problem. Thus, the question of understanding the role of focus can be reduced to the question of how complexity of a problem affects the search process, the central question in Kaufmann's (1993) analyses.

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[2] Non-zero values are insignificant and due to the random nature of this model.

[3] If independent, there are no positive or negative externalities between the search processes of the two sub-problems. The focus of attention affects only how long it takes to find a solution to a sub-problem, but not the performance of this solution.

In our study, we argue that we observe the mid-term liability because it becomes increasingly less likely that searching core choices is successful. Focusing search on core choices always has higher risk of failure than focusing on peripheral choices. Only in the very long-run does the former have a lower risk: while organizations that focus on peripheral choices have already converged to a peak, firms with a focus on core choices are still searching (and search might be still lead to improvements, i.e., there is a lower risk of failure)

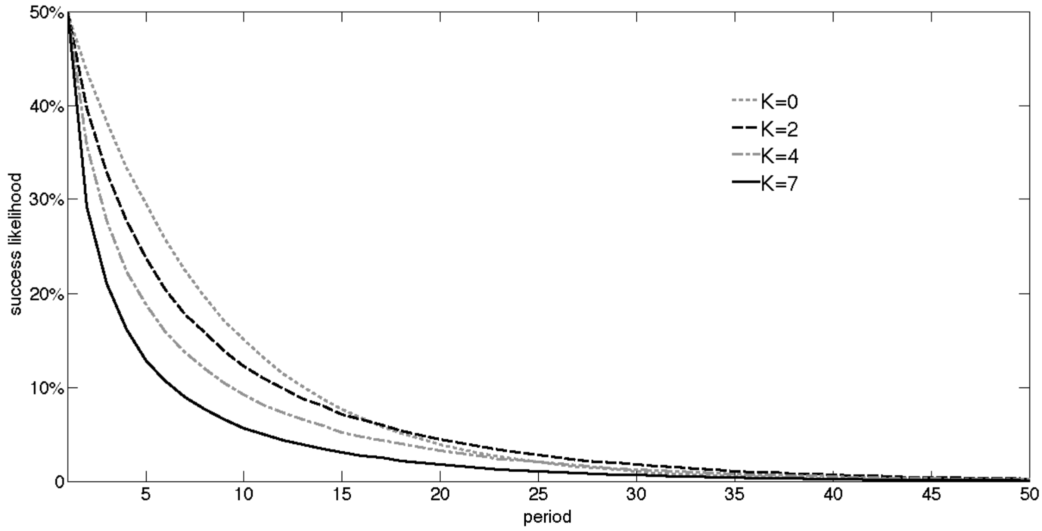
Focusing on core choices implies focusing on the more complex sub-problem. By implication, our finding suggests that the risk of failure increases in the complexity of the sub-system. This finding is consistent with Kauffman's (1993) observations on the effect of complexity on search success:

> *"Two other features of the K = 0 model with two alleles per locus are immediately understandable. If an adaptive walk starts anywhere and climbs via successively fitter one-mutant variants, then the number of fitter neighbors dwindles by 1 at each step upward. If the walk starts with a randomly chosen genotype, on average half of the N loci are already in the more favored allele, the other half are in the less favored allele. Therefore, the expected number of steps to the optimum is just N/2. This implies that walk lengths to the global optimum increase linearly as N increases."* (Kauffman 1993: 46)
>
> *"The expected fraction of fitter one-mutant neighbors dwindles by ½ on Each Improvement step. The landscape is entirely uncorrelated. Let the adaptive walk begin from the lowest ranked genotype. All its D neighbors are fitter, with rank-orders spread randomly between 2 and A^N. The walk samples neighbors at random and moves to the first fitter one encountered. Since those neighbors are spread uniformly in rank-order from just above the current genotype to the top, and since a random fitter neighbor is picked, on average, its rank-order lies halfway to the top. When the process moves to that neighbor, because it is expected to be halfway to the top, only half its one-mutant neighbors are still fitter. On average, each successive step jumps half the remaining distance to the top rack; hence each step the expected number of fitter one-mutant neighbors dwindles by ½.*
>
> *This argument replaces the mean of a family of such adaptive walks with a "mean walk." In short, on random landscapes the number of ways uphill increases rapidly. Recall, by contrast, that in K = 0 landscapes, the number of ways uphill decreases only by 1 at each improvement step."* (Kauffman 1993: 48)

In sum, with K=0, with each successful modification, the number of better variants in the local vicinity is decreasing by one. As the number of better variants decreases, so does the success likelihood of local search. With K>0, the number of better variants is decreasing by more than one for each successful modification. In the extreme case of K=N-1, each successful modification decreases the number of better variants by 50%. As a result, local search becomes increasingly unsuccessful as K increases.

In Figure S1-3, we report the success likelihood (the opposite measure of risk) of local search as a function of time (x-axis) for different levels of complexity (lines), ranging from K=0 to K=N-1=7.

Figure S1-3 Success Likelihood of Local Search



In t=1, the probability that local search is improving performance is 50%, independent of the problem's level of complexity. With a random starting position, on average, four of eight choices are incorrect, i.e., do not correspond to the global peak's position. With random local search, the probability that the search process targets one of these four choices is 50%. Yet, as the agent progresses the success likelihood is dropping much faster if she operates in a complex environment (solid black line) and the gap to non-complex problems in terms of the success likelihood widens over time. It is particularly large for intermediate points in time and closes again as the search results in convergence to a local or global peak.

Appendix S2: Robustness Test

In Table S2-1, we report the short-, medium-, and long-run performance differences between a focus on core (p=2/3) and peripheral choices (p=1/3) for alternative values of K_C and K_P (and K_{CP}=K_{PC}=1).

Table S2-1 Robustness in K_C and K_P

		Complexity Periphery							
		0	1	2	3	4	5	6	7
Complexity Core	1	+0.0009* -0.0009** +0.0053****							
	2	+0.0071**** +0.0058**** +0.0056****	+0.0075**** +0.0058**** +0.0053****						
	3	+0.0071**** +0.0038**** +0.0082****	+0.0066**** +0.0037**** +0.0090****	+0.0009* -0.0026**** +0.0018****					
	4	+0.0072**** +0.0002 +0.0100****	+0.0042**** -0.0016**** +0.0087****	+0.0025**** -0.0054**** +0.0020****	+0.0003 -0.0036**** +0.0009****				
	5	+0.0070**** -0.0046**** +0.0100****	+0.0040**** -0.0084**** +0.0031****	+0.0026**** -0.0093**** +0.0030****	+0.0024**** -0.0066**** +0.0011****	+0.0003 -0.0036**** 0.0000			
	6	+0.0033**** -0.0124**** +0.0030****	+0.0047**** -0.0127**** +0.0029****	+0.0044**** -0.0124**** +0.0033****	+0.0027**** -0.0098**** +0.0019****	+0.0017**** -0.0070**** +0.0008***	+0.0013*** -0.0038**** -0.0002		
	7	+0.0108**** -0.0123**** +0.0097****	+0.0114**** -0.0124**** +0.0095****	+0.0103**** -0.0126**** +0.0094****	+0.0042**** -0.0136**** +0.0021****	+0.0039**** -0.0097**** +0.0011****	+0.0022**** -0.0070**** +0.0007**	+0.0014*** -0.0031**** +0.0002	
	8	+0.0093**** -0.0122**** +0.0099****	+0.0105**** -0.0126**** +0.0097****	+0.0065**** -0.0154**** +0.0033****	+0.0045**** -0.0128**** +0.0019****	+0.0028**** -0.0101**** +0.0015****	+0.0030**** -0.0066**** +0.0006**	+0.0007* -0.0035**** +0.0004*	-0.0007* -0.0002 +0.0001

* p<0.1 ** p<0.01 *** p<0.001 ****p<0.0001

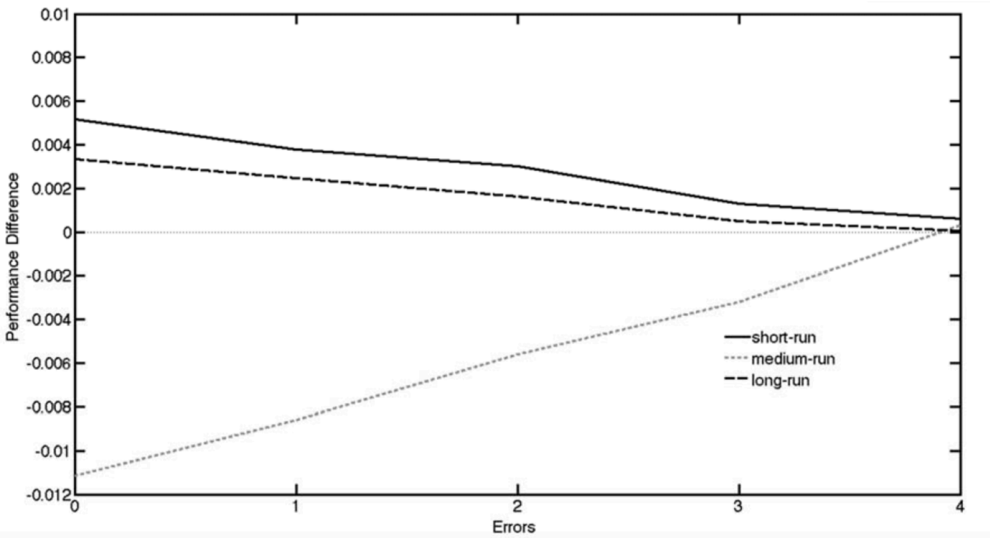
In each cell, the top entry reflects the short-run performance effect, the second the medium-run, and the third entry the long-run performance effect. Those combinations, which do not correspond to our key findings' pattern, i.e., positive effects of focus on core choices in the short- and long-run, negative effects in the medium-run, are highlighted (grey background color).

Except for extreme cases when the difference in complexity between core and peripheral choices are very small and if core choices exhibit a low degree of interdependence, our basic findings are very robust to changes in the complexity of both the core and periphery. Indeed, most effects are significant at p-levels below 0.0001.

Appendix S3: Focus Misfit

In our analysis, organizations are assumed to either focus on core or peripheral elements. For various reasons such as a lack of ability to identify core and periphery correctly or a lack of willingness to change some choices, there might be a misfit between search focus and the core periphery structure, i.e., organizations may end up focusing on a set of choices that contains a mix of core and peripheral choices. In Figure S3-1, we report the short-, medium, and long-run performance implications of such focus misfit (x-axis). For organizations with a focus on core choices, no misfit implies that the organization focuses its search efforts on core choices; if there is one misfit, all but one core choices are at the center of the organization’s focus and instead of this one neglected core choice, a peripheral choices is in the focus of the organizational search efforts.

Figure S3-1 Implications of Focus Misfit



The results suggest that the implications of focus are a linear function of the number of misfits. In the extreme case of four misfits (N/4=4) when an organization focuses on four core choices and four peripheral choices (neglecting four core choices and four peripheral choices), performance differences between a focus on core choices and peripheral choices disappear. However, as long as there are not too many misfits, the general pattern of results remains unaffected.

Appendix S4: Environmental Change

In the manuscript, we reported some exemplary results for non-architectural change and architectural change. In this appendix we provide additional details for these changes and discuss alternative forms of change. We use a non-hierarchical system (K_C=6, K_P=2,K_{PC}=K_{CP}=1) as an example to espouse the underlying dynamics and mechanisms of environmental change; the same mechanisms and dynamics also apply to all other core-periphery structures.

From our analysis (for example, figures 1,2, and 3 in the manuscript) of the effect of time horizon on the efficacy of focused search, we can directly deduce the optimal allocation of attention in the face of non-architectural environmental changes (figure 3 in the case of our non-hierarchical core-periphery structure). For non-architectural changes, the core periphery structure remains unchanged and the optimal allocation of focus depends on the frequency of changes. For example, if every five periods there are environmental shocks, like in Siggelkow and Rivkin (2005), that are so strong that the post-shock landscape is completely different from the pre-shock landscape (i.e., their correlation is zero) even though the core periphery structure remains unchanged, the firm faces a new landscape every five periods. Put differently, their pre-shock adaptations are worthless after the shock; basically, they have to start their search from a random position again. Thus, firms should seek to maximize their performance in the first five periods. With such a short time horizon, firms are always better off focusing their attention on core rather than peripheral choices. If, however, a shock occurs every 20 periods, firms may be better off focusing their attention on peripheral choices. If shocks occur only every 100 periods, a focus on core choices once again becomes better than a focus on peripheral choices. In other words, unless shocks are very rare or extremely frequent, a focus on peripheral choices will be optimal. If the shock is less complete (i.e., it has a lower magnitude), the relevant time horizon the firm needs to optimize for becomes longer since it may take several shocks to completely overturn the environment.

If environmental changes are architectural, the implications are less straightforward. With architectural changes, what was once a peripheral choice may turn into a core choice and vice versa. As a result, an organization that had focused on core choices before the environmental shock focuses on peripheral choices after the environmental choice (and vice versa). Let us assume a fundamental shock occurs every 20 periods, i.e., all core choices become peripheral choices and vice versa[4]. If organizations are unable to adapt their focus in the search process, environmental changes result in a shift of focus from core to periphery if the focus was on core choices and from periphery to core if the focus was on peripheral choices. Thus, to understand the implications of architectural changes, we have to understand the effects of focus misfit.

From our analysis in Figure S3-1 of the appendix, we know that the number of misfits has a linear effect on performance. Thus, an organization with no misfits pre-shock and will suffer from N/2 misfits post shock exhibits the same performance as an organization with some pre-shock misfits since an environmental shock may reduce some of these misfits. Thus, if organizations cannot adapt their focus to the changed core-periphery structure, on average, both core and peripheral choices receive equal focus.

The implications of all other forms of environmental change, less radical, more gradual, structural and non-structural environmental changes, can be deduced from this analysis (and our analysis on focus misfit).

Environmental changes may vary along the following dimensions:

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[4] Such frequent fundamental changes common in what Eisenhardt and colleagues (Bourgeois and Eisenhardt 1988; Eisenhardt 1989; Eisenhardt and Bourgeois 1988) refer to as high velocity environments. High velocity environments are characterized by "rapid and discontinuous change in demand, competitors, technology and regulation.

(1) Structural versus Non-Structural Change: Environmental changes may or may not alter the underlying core-periphery structure. If they alter the core-periphery structure, we call them structural (or architectural) changes.
(2) Magnitude of (Non-Structural) Change: Environmental changes may also vary in its extent. It might be radical or only incremental.
(3) Frequency of Change: The frequency of change reflects how often change events in the environment happen.
(4) Transition: The transition between the old and new performance landscape can be discontinuous or more gradual.

While there is an infinite number of ways of configurations along these dimensions (which makes its also impossible to provide analyses on all of them), to understand the impact of different types of environmental changes, one has to understand four things:

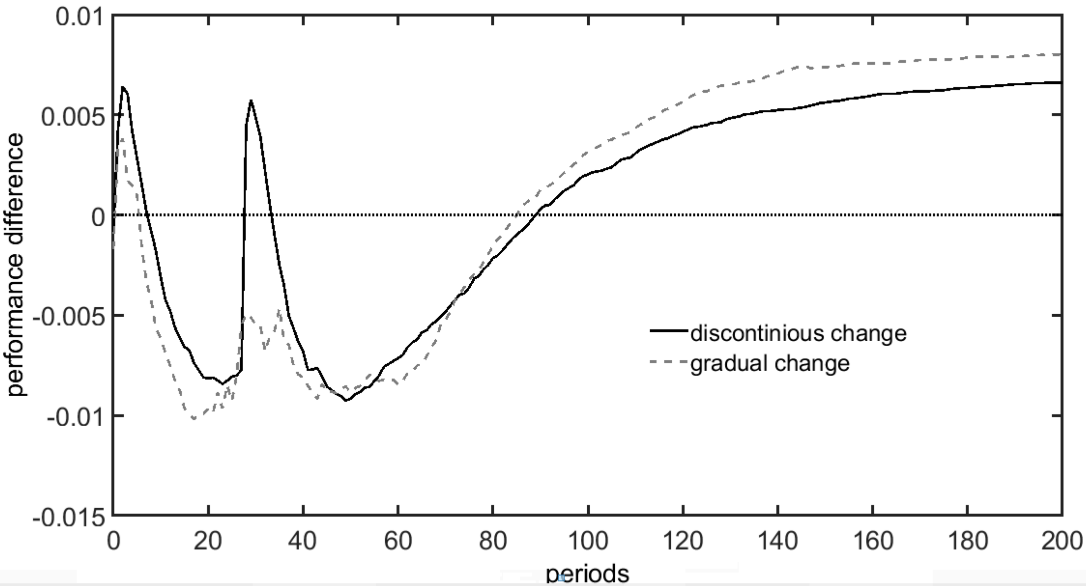
(1) An environmental change pushes the organization back on the learning curve. Prior learnings are devalued and, as a result, the organization is pushed back on the learning curve and performance decreases.
(2) How far the organization is pushed back is a linear function of the magnitude of change. In the extreme case of a radical change of magnitude N=16, the organization is pushed back to its starting position on the learning curve; with less radical changes, the push back is less strong.
(3) Gradual transitions can be conceptualized as a series of incremental, lower magnitude changes. For example, rather than experiencing a discontinuity of magnitude=10 in one period, an organization may experience environmental changes of lower magnitude=1 for 10 periods.
(4) Structural changes affect the core and periphery distinction and, thus, may also change the organization's intended focus. Put differently, an organization that seeks to focus its attention on core choices may end up focusing on peripheral choices. If the environmental shock is not affecting the core/periphery distinction, the organization's' focus is unaffected.

Below, we discuss some examples of different types of environmental changes in more detail.

Gradual versus Discontinuous Non-Structural Change: In Figure S4-1, we report the performance of focused search for a discontinuous change (black solid line) and gradual change (gray dashed line) around period 20. In both cases, all N=16 dimensions of the environment change. In the case of discontinuous change, this occurs in one period; in the case of gradual change, this occurs over 16 periods, i.e., in each of these 16 periods, a different environmental dimension changes. In the end, the environment has changed completely in both cases.

As discussed above, with a discontinuous change of high magnitude N=16, the organization is pushed back to the starting point (t=1) on the learning curve. With a series of gradual environmental changes (with a magnitude of one for each of the 16 steps), the organization is also pushed back a little bit in each period. Yet, since it learns in parallel, it can compensate some of the push back. Even after a series of small, gradual environmental changes, it never ends up at the starting point of the learning curve again. It might be pushed back only by a few periods. As shown in Figure S4-1, with a gradual change process, the organization is never pushed back to a time horizon for which a focus on core choices is superior.

Figure S4-1 - Gradual and Discontinuous Environmental Changes



Gradual versus Radical Structural Change: From our analysis of focus misfit (Figure S3.1), we know that implications of focus are a linear function of the number of misfits . With a radical shift every 20 period, the organization's focus is either a perfect fit or a complete misfit. If transitions are more gradual, the organization's focus may move gradually from a perfect fit to a complete misfit. Yet, since there are no non-linearities in the effects of focus misfit, qualitatively, our results remain unchanged. A gradual transition only has a dampening effect compared to a discontinuous change.

More Frequent versus Less Frequent Change: Understanding the temporal dynamics (Figures 1 to 3 in the manuscript) allows us deducing the effects of more or less frequent environmental changes. A non-structural shock in period t=20 implies that all pre-shock adaptations of the firm have lost their value. In other words, after the shock, the firm finds itself again in a random position (much like in t=1, when it was endowed with a random position). Thus, if we are interested in how extremely frequent changes (every 5 periods) as in Siggelkow and Rivkin (2005) affect the optimal allocation of attention, we can deduce from Figure 1 in the manuscript that for a time horizon of 5 periods, it is optimal to focus on the core. If the shocks are less frequent (and the time horizon over which the environment is stable), the optimal focus may shift towards peripheral choices. By the same logic, we can deduce the effects of shocks that are less severe in their magnitude, i.e., shocks that may not completely change the environment.

Non-Structural versus Structural Change: If the environmental shock is not affecting the core/periphery distinction, the implication of focus are unaffected; only the value of an organization's pre-shock adaptations, embodied in its current position on the performance landscape, are rendered useless. Put, differently, its post shock position on the performance landscape is a random position. Since in t=0, we also put organizations on random positions, the implications of a non-structural shock every 20 periods, can be deduced from looking at the performance in the first 20 periods.

References

Bourgeois, L.J., III, K.M. Eisenhardt. 1988. Strategic Decision Processes in High Velocity Environments. *Management Science* **34**(7) 816-835.

Eisenhardt, K.M. 1989. Making Fast Strategic Decisions in High-Velocity Environments. *Academy of Management Journal* **32**(3) 543-576.

Eisenhardt, K.M., L.J. Bourgeois, III. 1988. Politics of Strategic Decision Making in High-Velocity Environments. *Academy of Management Journal* **31**(4) 737-770.

Kauffman, S.A. 1993. *The Origins of Order: Self-Organization and Selection in Evolution*. Oxford University Press, New York.

Levinthal, D.A., H.E. Posen. 2007. Myopia of Selection: Does Organizational Adaptation Limit the Efficacy of Population Selection? *Administrative Science Quarterly* **52**(4) 586-620.

Rivkin, J.W., N. Siggelkow. 2003. Balancing Search and Stability: Interdependencies among Elements of Organizational Design. *Management Science* **49**(3) 290-311.

Siggelkow, N., J.W. Rivkin. 2005. Speed and Search: Designing Organizations for Turbulence and Complexity. *Organization Science* **16**(2) 101-122.