Inertia in Routines: A Hidden Source of Organizational Variation

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ABSTRACT

Traditionally, routines have been perceived as a primary source of inertia, which slows down organizational change and hinders organizational adaptation. Advancing prior research on routine dynamics, this study examines how inertia in routines influences the process of organizational adaptation, both in the absence and presence of endogenous change of routines. Contrary to conventional wisdom, our analysis suggests an overlooked mechanism by which routine-level inertia may help, rather than hinder, organization-level adaptation. We demonstrate this mechanism by using a simple theoretical model in which the organization is characterized as a configuration of interdependent routines, and study the process by which this configuration adapts to cope with its task environment. We find that inertia in routines may engender potentially useful variation in the process of organizational adaptation because reduced rates of routine-level changes may lead to temporal reordering when these changes are implemented. In our nuanced perspective, inertia is not only a consequence of adaptation or selection as perceived in prior research, but also a source of variation that turns out to be useful for adaptation. This logic is helpful to better understand why apparently inertial organizations keep surviving and from time to time exhibit outstanding performance. We conclude by discussing how this advanced understanding of the role of routines in organizational adaptation helps elaborate the theory of economic evolution.

Keywords*: Organizational Routines, Organizational Inertia, Organizational Change, Organizational Adaptation, Evolutionary Theory*

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INTRODUCTION

Do routines hinder or help organizational adaptation? Addressing this question is important for elaborating our understanding of economic evolution because routines play a central role both for selection and retention processes (Hannan and Freeman 1984, Nelson and Winter 1982). Routines have the important property that they enable repeatable and reliable performance of organizational activities (Holland 1975, Nelson and Winter 1982). In contrast to the desirable property of stability, such continuity or reproducibility also generates more questionable properties such as strong inertial forces and resistance to change (Amburgey et al. 1993, Hannan and Freeman 1984). While problematic for individual organizations, organizational inertia increases the impact of selection forces, and thereby stimulates evolutionary change at the population level (Hannan and Freeman 1984). Organizations do also adapt over time, however, and both selection and adaptation drive change (Levinthal 1991). Research suggests that routines have a double role in processes of organizational adaptation. They are associated with a strong drive towards organizational stability and inertia. At the same time, however, routines also facilitate organizational change and adaptation (e.g., Adler et al. 1999, Amburgey et al. 1993, Feldman and Pentland 2003, Feldman 2000, Levitt and March 1988, Nelson and Winter 1982). The fact that routines are associated with both stability and change gives them a central role, not only for understanding organizational reliability, survival and inertia in economic evolution (Hannan and Freeman 1984), but also in explaining how organizations achieve efficiency and flexibility in their adaptive processes (Adler et al. 1999).

As we consider the role of routines in organizational adaptation, however, we eventually confront an old dilemma related to routines as a target of change: The stability of routines hinders organizational adaptation since adaptation involves changes to the routines. Although prior research has identified several mechanisms by which routines may facilitate organizational adaptation, those mechanisms do not resolve, but rather bypass, the stability-change dilemma. This study is an attempt to fill in this theoretical gap.

Building on recent research on routines, we examine the implications of routine dynamics for organizational adaptation. In particular, we focus on investigating the conventional wisdom behind the stability-change dilemma that routines generate inertial forces, as a byproduct of their stability, which slow down organizational change and thus hinder organizational adaptation. By developing theory grounded in a formal model, we unpack the adaptive process of an organization consisting of interdependent routines. Using this theoretical platform, we examine the consequences of routine-level inertia for a process of organizational adaptation that involves changes to the routines. We do so both in the absence and presence of endogenous change of routines.

Contrary to conventional wisdom, our analysis finds that inertia in routines may engender variation that is potentially useful for organizational adaptation: Delays in the implementation of planned changes to routines may cause unintended variation in the pace and sequence with which the changes and their effects take place. In the ongoing process of organizational adaptation, the consequences of such unintended variation via *temporal reordering* of the implementation of planned changes are selectively retained. The stability of routines then facilitates the retention of the selected changes and consequences. Routine-level inertia, in conjunction with bounded rationality, therefore plays a hidden role of generating and retaining potentially useful variations in organizational adaptation.

THEORY

Routines as a Source of Organizational Inertia

Traditionally, organizational routines are seen as stable over time, exhibiting low variance in actions, and in performance between one period and the next (Cohen and Bacdayan 1994, Feldman and Pentland 2003, Gersick and Hackman 1990, Hannan and Freeman 1984, March and Simon 1958, Nelson and Winter 1982). As selection forces and processes favor low variance in performance, stability provides advantages for survival (Hannan and Freeman 1984, Levinthal and Posen 2007, Singh et al. 1986). This advantage, however, comes at the cost of inertia. This is because high reproducibility or continuity, by its very nature, implies resistance to change (Hannan and Freeman

1984). Routine-induced resistance to change, even in the face of negative performance feedback, is a remarkable empirical regularity in organizations (Gilbert 2005, Howard-Grenville 2005, Kilduff 1992, Leonard-Barton 1992, Nelson and Winter 1982).

In organization theory, inertia is usually conceptualized as *reduced rate of change* (i.e., slow and/or insufficient response) relative to the occurrence of opportunities and threats in the task environment. As Hannan and Freeman (1984: 151) write, 'structures of organizations have high inertia when the speed of reorganization is much lower than the rate at which environmental conditions change.' Note that with a short window of observation, a slow speed of change might mean no change occurring within the time horizon considered, so that inertia is also sometimes associated with absence of change. A number of factors and processes can contribute to inertia. Rumelt (1995), for instance, identifies five sources of inertia: distorted perception, dulled motivation, failed creative response, political deadlocks, and action disconnects (the latter including 'embedded routines'). The management literature also identifies various sources of resistance to change (Jones 2013) at the organization level (power and conflict, differences in functional orientation, mechanistic structure, organizational culture), at the group level (group norms, group cohesiveness, groupthink, escalation of commitment), and at the individual level (uncertainty and insecurity, selective perception and retention, habits – the latter being the individual-level counterpart of organizational routines, Hodgson and Knudsen, 2010). Finally, the project management literature has identified several factors that cause delay in projects, such as complexity of project design, ambiguity in specifications, changes in conditions, design changes, limited flexibility, design errors, operational errors, shortage of inputs, lack of user involvement, lack of experience, poor communication, conflicts, reluctance to change, and differences in geographical locations (Abd El-Razek et al. 2008, Cummings et al. 2009, Doloi et al. 2012, Gündüz et al. 2013).

Amongst those many potential causes, this study focuses on inertia induced by the internal structure and dynamics of routines as we examine the implications of routine dynamics for organizational adaptation. Researchers have identified complexities and processes associated with routines as a primary source of organizational inertia (Pentland and Feldman 2005, Pentland et al.

2011, Rumelt 1995). As Rumelt (1995: 9) explains, routines (embedded in an organizational context) are complex processes that might include tacit knowledge of how certain steps are performed so that no one may have a complete understanding of the whole process. Thereby, changing one aspect of a process may have significant unanticipated consequences for other parts of the organization. Such interwoven patterns of action, in conjunction with risk of change, generate inertial forces. As such, organizational routines are made of interacting parts and processes, and the inertial tendency of routines is largely driven by forces that reinforce patterns of interactions within and between routines (Axelrod and Cohen 2000, Cohen and Bacdayan 1994, Feldman and Pentland 2003, 2008, Pentland et al. 2011). What is notable is therefore that inertia in routines is a byproduct of the ability and efforts to accomplish demanded tasks in a repeatable and reliable manner (Argote 1999, Baum and Singh 1994, Cyert and March 1963, Feldman and Pentland 2003, Hannan and Freeman 1984, March and Simon 1958, March 1991, Nelson and Winter 1982). In contrast to other sources of inertia that just produce delays and slow down change, this is why routines are a special source of inertia – and why we focus on routine-induced inertia.

Routines as a Source of Organizational Adaptation

The view of routines as a source of organizational inertia is, however, contrasted by a more nuanced view that portrays routines as a source of organizational adaptation (Adler et al. 1999, Bigley and Roberts 2001, Burgelman 1994, Feldman and Pentland 2003, Feldman 2000, Levitt and March 1988, Moorman and Miner 1998, Nelson and Winter 1982). This alternative view has identified several mechanisms through which routines can facilitate organizational adaptation.

Recombination of Routines. Routines provide stable building blocks that can be flexibly recombined in response to environmental conditions (Amburgey et al. 1993, Becker et al. 2006, Bigley and Roberts 2001, Galunic and Rodan 1998, Nelson and Winter 1982, Winter and Szulanski 2001). Thereby, routines can maintain stability and, at the same time, promote flexibility as the organization is adapting to new or changed circumstances. The idea of stable building blocks that provide flexibility through recombination also features prominently in the literature on improvisation,

which generally points to recombination of stable routinized procedures as a powerful source of variation (Moorman and Miner 1998).

Routinizing change-tasks. Organizational routines are usually associated with exploitation and refinement (Levitt and March 1988). However, exploration, or change-tasks, might also be routinized (Nelson and Winter 1982: 18, 134). Routines can, accordingly, promote change when change-tasks are accomplished in a stable and systematic fashion. For example, it has been observed how 'meta-routines' (higher level routines that change the state of lower-level routines) facilitated efficient performance of non-routine tasks and contributed to the exceptional combination of flexibility and efficiency achieved by an automotive firm (Adler et al. 1999). For another empirical example, it has been observed how routines to promote systematic exploration, such as routines applied in brainstorming meetings, contributed to the innovativeness of a design firm (Hargadon & Sutton, 1997). Similarly, any routinized approach to product development, such as going through the sequence of go/no-go decisions defined by stage-gate models (Cooper and Kleinschmidt 1986) might be considered as a stable and systematic process that generates variation in the product portfolio. As well documented in Burgelman's (1994) study of Intel's shift from the memory business to the microprocessor business, an inertial process or a strict rule of decision making sometimes generates unexpected, good outcomes that might not have been achieved without such inertia.

Routinizing Resource Allocation. To achieve both stability and change (or, efficiency and flexibility), organizations partition the portion of their resources that are dedicated to routinized exploitation (reduces variation) and routinized exploration (generates variation). Further, they adapt the portion of resources for exploration and exploitation over time, at the organizational and/or individual level. These processes of resource allocation in the spatial and temporal dimensions can also be accomplished in a systematic, repeatable manner. Different mechanisms for implementing structural (i.e., spatial) partitioning have been identified in prior research, both at the organizational level and at the level of individual job roles. At the organizational level, separate organizational units can specialize in either exploration or exploitation (Tushman & O'Reilly, 1996). For example, Adler et al. (1999) showed differentiated subunits that worked in parallel on routine and non-routine tasks

were an important source of the exceptional combination of flexibility and efficiency achieved by the automotive firm they studied. At the level of the individual actor, it is possible to define distinct roles that are dedicated to either exploration or exploitation (Adler et al., 1999). Desired mixtures of exploration and exploitation can be achieved by design of a particular job role (job enrichment), or by switching between job roles. Switching between job roles can also be implemented by design so that a large number of employees switch roles frequently (Adler et al., 1999), or by reassigning personnel to different positions within the organization (Bigley & Roberts, 2001). Further, individuals who are capable of exploration and exploitation can be situated in an organizational context that can induce them to switch between exploration and exploitation (Birkinshaw and Gibson 2004). On a larger scale, organizations may engage in temporal bracketing or cycling between periods of exploration and exploitation – see literatures on organizational search (e.g., Chen and Katila 2008, Siggelkow and Levinthal 2003, Winter and Szulanski 2001), organizational ambidexterity (e.g., Birkinshaw and Gibson 2004, Gupta et al. 2006), and vacillation (e.g., Boumgarden et al. 2012, Nickerson and Zenger 2002).

Endogenous change of routines. Feldman and Pentland point out that the internal structure and dynamics of routines can endogenously generate changes to the routines (Feldman and Pentland 2003, Feldman 2000). Highlighting agency of the participants, they argue that routines are an 'effortful accomplishment', in which agents might reflect on and adapt the routine, for instance reacting to performance feedback, to improve the routine, or to cater to specificities of the situation (Feldman 2000). Pentland et al.'s (2010, 2011) longitudinal analysis of an invoice-processing routine in four organizations showed that the same routine can generate different patterns of action (Pentland et al. 2010), and that such patterns of action may change over time, even without 'outside interventions' (Pentland et al., 2011). In this perspective, organizational routines consist of interacting parts, and the interaction between them 'creates an on-going opportunity for variation, selection, and retention of new practices and patterns of action within routines and allows routines to generate a wide range of outcomes, from apparent stability to considerable change' (Feldman and Pentland 2003: 94).

Routine-Level Inertia and Organization-Level Adaptation

In explaining how routines facilitate organizational adaptation, the mechanisms discussed in prior research, except endogenous change of routines, rely on the stability of routines: flexible recombination of stable routines, stable (systematic) approaches to exploration, or stable (repeated) allocation of resources to change-tasks. Although the stability of routines plays a supporting role, what actually generate change in those mechanisms are the efforts and processes dedicated to change itself. Considering routines as the primary *targets* of change, however, it has long been taken for granted that their stability undermines such an approach. Therefore, the idea that stability or inertia in routines may help, rather than hinder, the organizational process of adapting the routines in some sense defies common assumptions. This, in part, explains why this idea has not yet undergone systematic examination.

The stability-change dilemma reflects an important gap in extant research on routines and organizational adaptation: While it is likely that the micro-processes of routinized actions influence organizational phenomena, extant knowledge about the causal link between routine-level inertia and organizational inertia/adaptation is scant (Abell et al. 2008, Salvato and Rerup 2011). For instance, Birnholtz et al. (2007), in their study of a summer-camp organization, find that the 'coherent content of the ensemble of dispositions generates the distinctive actions of the organization' (Birnholtz et al. 2007). However, not much is known concerning the mechanisms by which individual dispositions generate the distinctive actions of the organization. Research in information systems has also struggled with a similar issue of causal ambiguity residing between different organizational levels. Butler and Gray's (2006: 213-214) inquiry, for example, reflects this issue: "While existing work contributes to our understanding of information system reliability, it leaves largely unexamined questions of how system reliability translates into reliable organizational performance… It remains unclear what happens when routines and systems are themselves emergent and composed of imperfect, evolving components." More generally, understanding aggregation or translation between individual learning and organizational learning, and the role of routines therein, is an important theoretical puzzle left in research on organizational learning: As Argote and Miron-Spektor (2011: 1126) put it, "Although individual learning is necessary for group and organizational learning,

individual learning is not sufficient for group or organizational learning. For learning to occur at these higher levels of analysis, the knowledge the individual acquired would have to be embedded in a supraindividual repository so that others can access it. For example, the knowledge the individual acquired could be embedded in a routine or transactive memory system." Scholars have therefore called for work spelling out the mechanisms that link properties and processes at different organizational levels, identifying a gap that is still wide open.

In the absence of systematic knowledge about dynamics and interactions between different levels of organizations, it is tempting to fall back on considering organizations as unitary actors. Such a perspective would suggest equating routine-level inertia with organization-level inertia: If (the internal structure and dynamics of) routines generate resistance to change, they also increase organizational inertia and thereby hinder organizational adaptation. This perspective can, for instance, be found in Hannan and Freeman's seminal work on structural inertia. Referring to their famous argument that selection within a population of organizations in modern societies favors organizations whose structures have high inertia, they argue that 'the argument of this chapter can be applied either to the organization as a whole… or to the individual routine' (Hannan & Freeman, 1989: 76-77). As they are aware, they 'have considered organizations as unitary actors, either adapting to their environments or remaining inert' (Hannan & Freeman, 1989: 76-77). As the example shows, such a unitary-actor perspective is not uncommon. While facilitating analysis, such a perspective is likely to hide some of the mechanisms by which routine-level inertia has nontrivial consequences for organizational adaptation. As a result, we often face puzzling examples and explanations about the relations between routines and organizational adaptation, as discussed above.

In this study, we relax the unitary-actor assumption and unpack the dynamics that arise from the interactions between stability and change at the level of routines, and adaptation at the organizational level. We do so by modeling an organization as a configuration of interdependent routines and by analyzing how routines, as generative systems that can generate both stability/inertia and endogenous change, influence the process and outcome of organizational adaptation. In particular, our analysis focuses on scrutinizing the intuitive but still ambiguous causal link between routine-level inertia and

organizational adaptation. Among various causes of inertia, we focus on inertia generated from the internal structure and dynamics of routines, as a byproduct of the ability and efforts to accomplish demanded tasks in a repeatable and reliable manner (Argote 1999, Baum and Singh 1994, Cyert and March 1963, Feldman and Pentland 2003, Hannan and Freeman 1984, March and Simon 1958, March 1991, Nelson and Winter 1982).

Recent research on endogenous change of routines provides a useful insight that helps understand the mechanism proposed in this study. Inertia in routines resists and slows down the implementation of planned changes to the routines, which generates divergence between choices (planning) and actions (implementation). Just like divergence between the ostensive and performative aspects of routines leads to variation in the process of performing planned routines (Feldman and Pentland 2003, Pentland and Feldman 2005, 2008), the choice-action divergence may also engender variation in the process of implementing planned changes. Routine-level inertia therefore plays a critical role in generating variation in the process of organizational adaptation. We articulate and demonstrate this idea with our formal model. By tracking routine-level processes of organizational adaptation, we systematically analyze the underlying mechanism in our simulation experiments.

MODEL

Our model is designed to examine how the dual nature of routines (i.e., stability/inertia and endogenous change) influences organizational adaptation, while controlling for other mechanisms covered in prior research such as recombination of routines and partitioning/allocation of resources (i.e., there is no element in our model that effectuates such mechanisms). Our focus lies on the *implications* of the dual nature of routines rather than on the various reasons why routines have such a dual nature. For this reason, our model formalizes the effects of the dual nature of routines on the process of organizational adaptation, rather than the internal structure and dynamics that ultimately can explain the nature of routines. In other words, we connect research on routine dynamics (e.g., Feldman and Pentland 2003, Feldman 2000) and research on organizational learning/adaptation (e.g., Argote and Miron-Spektor 2011, Levinthal and March 1993, Levinthal 1997, Levitt and March 1988,

Rivkin and Siggelkow 2003, Simon 1991).

In doing so, we carefully designed each element of our model not only to be consistent with the contemporary views on routines (Cohen and Bacdayan 1994, Feldman and Pentland 2003, Nelson and Winter 1982, Pentland and Feldman 2005, Pentland et al. 2011, 2012), but also to be simple enough as compared to the canonical model of organizational adaptation (Levinthal 1997). This approach of simple modeling has the notable advantage that it allows us to systematically analyze the complex dynamics residing between the routine and organization levels. Specifically, the model builds on three key assumptions or features of routines that are widely-accepted in modern theories of routines: (1) routines are generative structures, which may generate different patterns of actions (Becker 2005, Feldman and Pentland 2003, Pentland and Rueter 1994, Pentland et al. 2012), (2) efforts to develop routines enhance the stability of action patterns (Cohen and Bacdayan 1994, Cohen 2007), and (3) such efforts of routinization, however, also strengthen inertial forces that resist and slow down change of routines (Amburgey et al. 1993, Hannan and Freeman 1984).

The specific model setup is described in the following. To facilitate understanding of the model, a simple exemplary case of the overall model procedure is illustrated in Figure 1. Hiring routines are used as an illustrative example. As Feldman (2000) notes, hiring routines are typical examples of routines, cited by Nelson and Winter (1982), and at the focus of both empirical research and theory development in research on routines (Feldman and Pentland 2003, Feldman 2000, Rerup and Feldman 2011).

===== Insert Figure 1 about here =====

An Organization as a Configuration of Routines

In our model, an organization is assumed to deal with N tasks and have a corresponding routine for each task. The organization, therefore, consists of a set, or bundle of N routines (Nelson and Winter 1982). Each routine can generate different patterns of action. For simplicity, we consider the case where each routine may generate two different patterns of actions to accomplish a given task. That is, an organization is characterized by N routines, and each routine can be expressed in two

different action patterns, one which we summarize under the label '0', and another one with the label '1' (Feldman and Pentland 2003, Pentland 2003a). Think of, for instance, a hiring routine that is based only on screening documents supplied by the applicants, vs. a hiring routine that also includes one interview for the applicants who have passed screening of their documents. This expression is perhaps the simplest possible way to model routines that may vary between different states or patterns of action. One might think of routines that admit more than two states. The model, however, is general enough in the sense that a set of routines could be interpreted as subroutines that constitute a routine of more-than-two states. For instance, an organization of four routines with two distinct states (0, 1, 1, 0) could be viewed as an organization of two routines with four distinct states (01, 10). In the hiring example, there might be different kinds of interviews (and corresponding routines), such as a one-hour interview or a one-day assessment center. This issue of granularity is therefore a matter of abstraction, while the logic behind the suggested mechanism is not limited to a certain level of abstraction. Rather, what matters in practice would be the *comparability* of routines (Becker 2005, Pentland et al. 2010). When routines have comparable states that have different performance implications, it is possible to identify the superior routine that would improve performance. For instance, knowing that two hiring routines differ with regard to the presence of an 'interview' component helps draw conclusions about the role of interviews in the hiring process.

The pattern of N zeros and ones thus captures the organization-wide configuration of multiple routines. More formally, *an organization is represented as a configuration of N routines (Nelson and Winter 1982),* $X = \{x_1, x_2, \ldots, x_N\}$*, each of which has a state of either 0 or 1*. Thus, the number of distinct organizational forms corresponding to the configurations of routines amounts to 2^N. The objective of the organization is to find the appropriate configuration of its routines (i.e., desirable patterns of action) to cope with its task environment.

Organizational Fit with the Task Environment

As such, the organizational problem resembles the classic problem of search in a multi-dimensional space (Kauffman 1993, Levinthal 1997). Therefore, we employ the widely used NK

landscape to formalize the payoff structure for the organization of a set of routines. This approach has the obvious virtue of providing a straightforward way to formalize interactions among multiple interdependent routines. Note that the NK model of fitness landscape was originally developed to formalize and analyze the evolution of biological organizations, in which the configurations of genes vary over time (Kauffman 1993). Given Nelson and Winter's (1982) notion of organizational routines as the equivalent of genes in organizations, it is therefore very natural, even if not yet done, to apply the NK model to studying the role of routines in organizational adaptation.

Every routine makes a distinct contribution to overall organizational fitness in the given task environment and its contribution may be influenced by other routines with which it is interdependent. For instance, the hiring routine contributes to the organization's fitness, as it influences the population of human resources in the organization as well as its fit with the competences required by the environment. Moreover, the hiring routine may be constrained or supported by the budgeting routine because the hiring process should not begin before the budget for the position has been approved (Feldman & Pentland, 2003: 104), and the budgeting process may determine the feasibility of including effective interviews and exercise pressure for speeding up the hiring process so it is concluded before a certain date. Such interdependence between routines is formalized in the following way: *A routine i's fitness contribution* ω_i *depends on the states of a predefined set* D_i *of K other routines*. When K=0, each of the N routines are independent. When K>0, the search for improving the configuration of routines becomes more difficult because the change in one routine influences the performance of other routines. The K routines that each routine depends on are randomly assigned to control for the effects of the structure of interdependences. Thus, a routine may be independent, dependent on other routines, or influence other routines; it is possible that a routine may both affect and be affected by other routines.

$$\omega_i = \omega_i(x_i; D_i), \text{ where } D_i \subset X \text{ and } x_i \notin D_i$$

The contribution value ω_i is treated as an independent and identically-distributed (*i.i.d.*) random variable drawn from the uniform distribution $U(0,1)$ for each configuration (x_i; D_i). For example, if a routine depends on two other routines (i.e., K=2), its fitness contribution has one of $8(=2^{1+2})$

predefined values that are all randomly and independently drawn from the uniform distribution. Organizational fitness, Ω, is a simple average of ω_i over the N routines:

$$\Omega = \frac{1}{N}\sum_{i=1}^{N}\omega_i(x_i; D_i)$$

Organizational Adaptation with Routine Inertia

Organizations adapt through an ongoing process of identifying, planning, and implementing incremental changes (Cyert and March 1963, Levitt and March 1988, Simon 1947). Given the focus of this study, as discussed in the previous sections, we consider organizational adaptation as a process of changing the existing routines that make up the organization (Nelson and Winter 1982) to enhance organizational fit with the task environment. In our model, to control for the effect of the strategy or capability of allocating attention and resources, a randomly chosen routine is assessed in each time period: *The focal routine is randomly chosen and a change of its current state (i.e., 0 to 1 or 1 to 0) is planned only if the change enhances organizational fit (Ω) with the task environment (Levinthal 1997)*. The merit of changing a routine is evaluated on the basis of the status quo, i.e., the currently operative routines. For instance, in the endeavor to improve an organization's efficiency, decision makers might scrutinize the hiring routine (by intention or by chance) and ask whether changing it from having a one-hour job interview to a one-day assessment center might lead to improved efficiency of the hiring process and thereby benefit the organization. Note that we don't assume perfect rationality or omniscience of the decision makers. Rather, our assumptions are consistent with prior models of organizational adaptation which control for the apparently beneficial effects of superior rationality or foresight by assuming random allocation of attention and simple local search (e.g., Ethiraj and Levinthal 2004a, Levinthal 1997, Rivkin and Siggelkow 2003, Rivkin 2000). More specifically, the model formalizes the fundamental tradeoff between exploitation and exploration because currently beneficial changes (exploitation of the opportunities for improvement) may inhibit further exploration for an improved search path (Cyert and March 1963, Levinthal and March 1993, March 1991, Simon 1947).

Even when changing a routine is considered beneficial and the organization plans to implement

the change, however, the organization suffers from resistance to change and reduced rate of change because of inertia at the routine level. As discussed above in the theory section, many other factors can also lead to such inertia. This study, however, focuses on routine-induced inertia as a byproduct of the stability or reliability of routines. In contrast to prior models of organizational adaptation (e.g., Ethiraj & Levinthal, 2004a; Levinthal, 1997; Rivkin & Siggelkow, 2003; Rivkin, 2000), the planned changes are not implemented immediately in our model, but with some time lags or delays. To use the hiring routine example, while decision makers come to the conclusion that an assessment center will improve the efficiency of the hiring process and decide to have a one-day assessment center rather than a one-hour interview for the candidates who passed screening of their documents, human resource staff does not immediately start carrying out the assessment center rather than one-hour job interviews. This is because they may be reluctant, cautious, or simply because it takes time to implement any change to existing hiring routines. It is, indeed, hard to think of any real-world example of routine change that is implemented instantaneously.

We formalize the reduced rate of change that is due to routine-level inertia in the simplest possible way: *In a given time period, planned change(s) take(s) place with a probability of 1-R (0≤R≤1)*. If not implemented in that time period, a planned change may be implemented with the same probability in the following period, and so on. The parameter R represents the degree of inertial forces or resistance to change at the routine level. When R=0, a planned change is promptly implemented and its effect is observable in the next period – as in the canonical local search models (e.g., Levinthal 1997, Rivkin and Siggelkow 2003, Rivkin 2000). As R increases, however, it takes longer time, on average, before a planned change is implemented and before its effect is observed and can be taken into account when subsequent changes to the routines are considered. When R = 0.9, for instance, the probability that the implementation of a change will take place in a given time period is 0.1, and the probability that the implementation will take more than 10 time periods is 0.9^{10}. As such, the time lag between planning and implementation is stochastic in our model, which reflects various

uncertainties and contingencies present in reality.[1]

Endogenous Change of Routines

In addition to the top-down managerial efforts of organizational adaptation, participants in a routine (and their interactions) may also introduce variation in the performance of the routine through efforts to achieve improvement, improvisation, or simply by mistake (Feldman and Pentland 2003, Feldman 2000). For instance, pooling the interview of several candidates in an initiative to improve the hiring process (Feldman 2000), a staff member might substitute the one-hour job interview with a small assessment center. Such endogenous change of a routine, however, may also be suppressed by the efforts and processes of routinization (Birnholtz et al. 2007, Cohen and Bacdayan 1994, Pentland et al. 2011) as routine-induced inertia is a byproduct of the ability and efforts to accomplish demanded tasks in a repeatable and reliable manner (Argote 1999, Baum and Singh 1994, Cyert and March 1963, Feldman and Pentland 2003, Hannan and Freeman 1984, March and Simon 1958, March 1991, Nelson and Winter 1982). In other words, the stability or inertia of a routine tends to reduce variations from both its "inside" and "outside". In the hiring routine, for example, when colleagues in the HR department who also do hiring hear that several candidates were interviewed together in the form of an assessment center, they might insist on individual interviews to maintain the well-practiced routine as it is (e.g., for coherence or truce), or might bypass the new hiring routine (Feldman 2000: 622).

We formalize the endogenous change of routines and the stability of routines (i.e., suppressing such endogenous change) in the simplest possible way: *In each time period, the state of a routine changes (flips to either 0 or 1) with a probability of E(1-R), regardless of the presence of a plan to change it*. The model parameter E ($0 \leq E \leq 1$) denotes the potential of endogenous change of a routine, which arises from the internal structure and dynamics of routines (Feldman and Pentland 2003, Feldman 2000). Note that endogenous change at the routine level may be beneficial or detrimental at

[1] In addition to the time lag between planning and implementation, there can also be expectations about the extent of such a time lag, and differences between expected and realized time lag. We bypass those aspects and focus on modeling routine-level inertia as a form of reduced rate of change – i.e., the positive relation between R and (average) time for implementation.

the organization level: Because of bounded rationality, agents do not have the capability to figure out and implement only beneficial, perfectly coordinated changes for the organization; organizational complexity, agency problems, or internal politics can also frustrate the implementation of beneficial changes at the organizational level (Cyert and March 1963, March and Simon 1958, Milgrom and Roberts 1992, Simon 1947). Technically, we control for the possibility that the individual capability to identify beneficial changes has only positive effects on organizational adaptation, and only capture the possibility of endogenous change of routines.

SIMULATION EXPERIMENTS

Our simulation experiments and analyses are designed to understand how inertia in routines influences organizational adaptation, given the possibility of endogenous change of routines. In the process of organizational adaptation, routine-level changes are evaluated, planned, and implemented. In our model, there are two sources of routine-level change: planned change (top-down managerial control from the outside of routines) and endogenous change (bottom-up variation from within routines). Therefore, we design two simulation experiments to systematically analyze how routine inertia (i.e., reduced rate of change at the routine level) influences organizational adaptation driven by the two sources of change. In the first experiment, we control for endogenous change of routines (i.e., E=0) and focus on the effects of routine inertia on organizational adaptation when driven solely by top-down managerial control. We compare the relative adaptation of organizations characterized by more or less inertial routines (i.e., different levels of R) and then proceed to unpack the mechanism underlying the observed differences in organizational adaptation. In the second experiment, we allow for endogenous change of routines (i.e., E >0) while the organization adapts its routines in a top-down manner. Here, our interest lies in how the effect of the mechanism revealed in the first experiment is influenced by the presence of endogenous change of routines.

Experiment 1: Organizational Adaptation without Endogenous Change of Routines

Simulation Setup

In each simulation run, an organization with a random configuration of routines engages in local

search (planning and implementing changes to its routines) to improve its fit with the task environment (Ω). The fitness landscape is predefined as specified in the model section. Note that endogenous change of routines is ruled out (E=0) in this first experiment. Across simulation runs, we vary the parameter R to examine the relation between the degree of routine inertia and organizational adaptation. We also vary the fitness landscape by regenerating it for each 100 observations with each value of R. The presented results for a certain value of R are therefore averaged over 10,000 simulation runs (100 observations on each of 100 different landscapes) so that the effects of initial conditions regarding the organization and the landscape are averaged out. Other default model parameters are set at N=10 and K=3 (a broad range of additional N and K values are considered in the subsection below on boundary conditions). Given N=10, the possible number of initial random configurations of routines is 1,024 ($=2^{10}$) so that the number of observations for each value of R is more than enough to achieve stochastic significance in the effects of the independent variables, R (and E in the second experiment).

Main Result: Adaptive Role of Routine-level Inertia

We first compare the relative adaptation of organizations characterized by more or less inertial routines. Extant theory would expect that organizations consisting of more inertial routines suffer stronger resistance to change in implementing new practices and systems that can lead to organizational improvement and, consequently, exhibit a slower pace of organizational adaptation or higher level of organizational inertia (e.g., Amburgey et al., 1993; Hannan & Freeman, 1984; Leonard-Barton, 1992; Limayem et al., 2007). Figure 2 presents the patterns of organizational adaptation over time for three representative cases of R. As extant theory would expect, we observe that routine-level inertia leads to organizational inertia – that is, inertia in routines slows down organizational adaptation (compare the highly inertial organization of R=0.9 with the less inertial ones of R=0.5 or R=0). This slower pace of organizational adaptation, however, is not the only consequence of routine-level inertia. In the long run, organizations with more inertial routines (R=0.9) outperform those with less inertial routines (R=0.5 or R=0). Figure 3 offers intriguing statistics of organizational

change from a different angle: Although organizations with more inertial routines exhibit a lower frequency of change (i.e., longer interval between changes), they search more broadly (i.e., making more changes in total).

===== Insert Figure 2 and Figure 3 about here =====

Mechanism of Variation: Unplanned Reordering of Planned Changes

Why do we observe the simulation result that apparently more inertial organizations could exhibit superior adaptability? In the model, we assumed that routine-level inertia reduces the rate of change at the routine level. It is therefore intuitive that routine-level inertia slows down organizational adaptation that involves changes to the routines. But, why does routine-level inertia lead to broader organizational search, and how could an increase in organizational inertia coexist with enhanced organizational adaptability? Our analytical efforts focus on understanding the underlying mechanism behind these counter-intuitive observations that emerge from the apparently simple, intuitive model assumptions.

Our analysis suggests that at the heart of the mechanism lies a hidden process in which planned changes are implemented in unplanned ways because of routine-level inertia. Figure 4 illustrates the overall process. First, inertia in routines slows down the process of changing the routines. Second, such reduced rates of routine-level changes lead to unintended variation in the pace and sequence of their implementation, and thus feedback. Lastly, such unintended variation caused by temporal reordering may generate unanticipated consequences (e.g., a cascade of changes) that are selectively retained in the subsequent process of organizational adaptation. Each step is explained in more detail in the following.

===== Insert Figure 4 about here =====

Delays in Implementation. As assumed in the model, the more inertia at the routine level (higher *R*), the longer time (on average) it takes to change a routine (Hannan and Freeman 1984). For instance, organizations with an older, more established hiring routine will confront more difficulties to change their hiring routines because of highly coherent, interdependent elements of the routine or because the roles and skills of participants in the routine are deeply embedded in the routine so they

usually ‘do not want to reinvent and renegotiate the hiring procedure’ (Feldman and Pentland 2003: 97).

Time lags between planning and (the accomplishment of) implementation are, in fact, prevalent in real organizations across public administration (Pressman and Wildavsky 1984) and business – e.g., delays in the implementation of new IT systems (Murray and Häubl 2007, Orlikowski 1996, Pentland and Feldman 2008, Polites and Karahanna 2012, 2013). A broad range of research on habits, routines, organizational change and implementation has identified established routines (and the individual-level habits they are built from) as an important source of resistance to change and thus delays in implementation, because of the tendencies or inertial forces of routines to reproduce prior patterns of action (Gersick and Hackman 1990, Hodgson and Knudsen 2010, Nelson and Winter 1982). Empirical research has also documented well how routines and habits generate resistance to change and slow down intended changes in an organizational context (Gilbert 2005, Kilduff 1992, Murray and Häubl 2007, Orlikowski 1996, Pentland and Feldman 2008, Polites and Karahanna 2012, 2013).

Notably, such routine-level inertia or reduced rate of change is a byproduct of the stability of routines (Hannan and Freeman 1984, Nelson and Winter 1982), in which reinforcing forces generated by the interactions between the components of routines (and associated artifacts) play a considerable role (Feldman and Pentland 2003, Pentland and Feldman 2005, Pentland et al. 2011). There are many other potential causes of delays in implementation, such as conflicts or lack of resources (Jones 2013). Routines are therefore not a necessary condition for delays in implementation of changes to routines, but routine-induced inertia is indeed a sufficient condition (Hannan and Freeman 1984, 1989, Polites and Karahanna 2012, 2013).

Variations Triggered by Reordering. When the causes and processes of such delays are beyond foresight and control, there is uncertainty about the point in time when the effects of the planned changes will actually take place and become observable as feedback for subsequent learning and decision making. This stochastic aspect of the pace of routine-level change, as formalized with the implementation probability of $1–R$, raises the possibility that planned changes are implemented in variable orders, which may cause unanticipated consequences in the process of organizational

adaptation.[2] For instance, imagine an organization introducing two changes to its hiring routines: centralizing the screening of applications for different parts of the organization (Feldman 2000), and requiring strict accordance of application documents with regulations (Rerup and Feldman 2011). The changes are supposed to be implemented simultaneously. But if the implementation of one of the two is delayed (more than the other), they will be implemented at different points in time or reordered.

As hinted at, reordering of planned changes may cause two other kinds of unintended variations in the process of organizational adaptation. First, the implementation of multiple changes, planned at different points in time, may coincide in time, so that only the compound effect is observable; or, vice versa. Second, a planned change to a routine may be cancelled (or replaced with a modified one) when the change is reconsidered after some changes are made to other routines that interact with the focal routine. While delays in implementation of planned changes to routines are not the only source of reordering of the changes and thus, are not a necessary condition, they are a sufficient condition as the simulation results show (see Figures 5 and 6). Figure 5 illustrates how routine inertia may engender such unplanned variations in the process of organizational adaptation.

===== Insert Figure 5 about here =====

Figure 6 shows how many times on average the three kinds of unplanned variation take place in a simulated organization during its adaptation process. The occurrence of each kind of unplanned variation is counted until the organization reaches a steady state (with no further organizational change), which is averaged over the 10,000 observations for each value of *R*. As shown, all of the three kinds of unplanned variation occur more frequently in an organization with more inertial routines (i.e., higher value of *R*). The frequencies of the three kinds of unplanned variations, however,

[2] This explains the small difference in the organizational fitness for R=0 and R=0.5. For such reordering of planned changes to occur, there should be "multiple" change-initiatives stacked in the implementation process. This condition is fulfilled if, roughly saying, implementation is slower than planning. Figure 3 shows that the rate at which the simulated organization figures out opportunities for improvement and plans change-initiatives is roughly 0.2 (1 change per 5 periods) in the absence of inertia in routines (R=0). Therefore, the rate of implementation needs to be lower than 0.2 or the value of R needs to be greater than 0.8 (= 1 – 0.2) to easily observe the effect of the suggested mechanism. In reality, organizations are likely to undertake a handful of change-initiatives at the same time. The value of R=0.9 would therefore appear to be fairly normal in real-world applications.

do not necessarily correspond to their relative contribution to organizational adaptation. Rather, their effects are interrelated. For example, one kind of unplanned variation may reinforce other kinds of unplanned variations by opening a door to further organizational adaptation. In reality, the relative frequency and contribution of the three kinds of unplanned variations might vary across contexts and conditions.

===== Insert Figure 6 about here =====

Exploration and Learning. More unplanned variations, in addition to planned changes by top-down management, imply that an organization has engaged in broader search – interestingly, as a consequence of inertia in routines that has been perceived as "variation-reducing." While there are many potential sources of broad search (e.g., cognitive representations, Gavetti and Levinthal 2000, Knudsen and Srikanth 2014) and reordering of planned changes is not a necessary condition for broad search, it is a sufficient condition as it adds to variation. If decision makers have limited ability to figure out desirable future changes (Simon 1955), there is room for unplanned variations to become a source of rewarding exploration in organizational search (e.g., Ethiraj & Levinthal, 2004; Knudsen & Levinthal, 2007; Levinthal & March, 1993; Siggelkow & Rivkin, 2005). This is because such unplanned variations may help get out of status quo traps caused by local search procedures that are typically favored by agents with bounded rationality. Once useful or detrimental variations are made, their effects influence subsequent decision making while pushing forward organizational exploration. In this process, it is more likely that useful variations, rather than detrimental ones, are selectively retained. This is because detrimental variations, whether or not observable and understandable, generate negative feedbacks and trigger subsequent changes that turn back, or offset, their effects (Cyert and March 1963). In this regard, the consequence of the reordered implementations, although small in itself, may have long-lasting effects, propagating opportunities and reasons for changing other related parts of the organization.

In the hiring routines example, suppose centralizing the screening of applicants has been suffering strong resistance and thus considerable delays while rewriting the employment ads to emphasize accordance of documents with regulations has been already done. The documents supplied

in applications (Rerup and Feldman 2011) might be interpreted differently when screening is still carried out in a decentralized manner at different places of the organization, potentially leading to unanticipated variation in the short list of candidates. As such, changes to hiring routines can have important unanticipated consequences even if the changes carried out might appear mundane (Feldman 2000: 619), for instance with regard to greater homogeneity of the human resource population in the organization (Feldman 2000).

The logic that variation (in a longitudinal sense) or diversity (in a cross-sectional sense) may facilitate exploration and learning has been known and documented well (Campbell 1960, Levinthal and March 1993, March 1991, Weick 1979). Research on unanticipated consequences has also pointed out that (small changes in) actions can generate unanticipated consequences (Merton 1936) because of interactions among choices, actions, and contextual conditions (MacKay and Chia 2013, Plowman et al. 2007), which may lead to radical changes (MacKay and Chia 2013). The latter part of our mechanism builds on these streams of research.

Boundary Conditions

As is the case for other known mechanisms, there are factors that might moderate or limit the effects of the suggested mechanism. From long-standing theoretical debates in the literature on routines and organizational adaptation, we have extracted a number of organizational and environmental factors. We have chosen those that are highly relevant to this study, can be rigorously formalized and analyzed along our model setting, and therefore may provide useful insights and implications.

Organizational Complexity. Research has found inertia to be a problem that is particularly pronounced in more complex organizations (e.g, Carroll & Hannan, 2000; Hannan & Freeman, 1984). Organizational complexity is usually assumed to increase with the number of elements (e.g., organizational size) and the degree of interdependence among them. In our model, the parameters N and K represent these two dimensions of organizational complexity, respectively. By varying either parameter while holding the other constant, we analyzed how the adaptation-fostering effect of routine inertia varies along the two dimensions of organizational complexity.

Our results show that the suggested mechanism holds regardless of the degree of organizational complexity. Figure 7 and Figure 8 present the results on the effects of N and K, respectively. As shown in the figures, our results are robust to changes in N and K as the simulated organization with more inertial routines exhibits a higher degree of organizational adaptation over the investigated, broad ranges of N and K.

===== Figure 7 and Figure 8 about here =====

Core Rigidity. Research also suggests that not only the degree of inertia, but also the distribution of inertia matters. The notion of core rigidity implies that the routines (or capabilities) at the core of an organization's activity system are more difficult to change (i.e., more rigid) than those at the periphery (e.g., Hannan & Freeman, 1984; Leonard-Barton, 1992). The conventional wisdom is that organizations with a greater degree of core rigidity are less adaptive – especially in the face of a significant environmental change that necessitates large-scale changes throughout the organization.

In our model setting, core rigidity is operationalized as a positive correlation between the degree of a routine's inertia and the routine's influence on other routines (i.e., the number of other routines that depend on it). We extended the baseline model to accommodate such routine heterogeneity in inertia by assigning different R-values to the N routines proportionally to their influence on performance (i.e., fitness contribution) of other routines. Technically, the degree of inertia of a routine i is assigned as:

$$R_i = (N \times R) \times \frac{(1+d_i)^G}{\sum_{i=1}^{i=N}(1+d_i)^G}$$

where d_i denotes the number of other routines that depend on routine i (i.e., the out-degree of routine i in the influence network of the interdependent routines), R is now the average inertia of the N routines, and G is the degree of core rigidity. Note that a routine depends on K other, randomly assigned routines so that the number of routines that a routine influences (d_i) may vary from 0 to N-1. By controlling G, we can vary the distribution of routine inertia and thus core rigidity while holding the average degree of routine inertia constant – the larger the value of G, the higher the degree of core rigidity. G=0 is the case of the baseline model where the routines are homogeneous in the degree of

inertia.

Our result on the effects of core rigidity on organizational adaptation confirms conventional wisdom. As shown in Figure 9, the adaptability of the simulated organization drops as the degree of core rigidity increases. This negative effect of core rigidity takes place on top of the positive effect of the suggested mechanism. That is, depending on the relative strength of the two effects, we may observe positive, negative, non-linear, or insignificant influence of (changes in) routine inertia on organizational adaptation.

===== Figure 9 about here =====

Environmental Change. An intriguing aspect of the suggested mechanism is that it contributes to organizational adaptation yet is generated by routine inertia which – according to received wisdom – should add to organizational inertia. Relatedly, an interesting aspect of a turbulent task environment is that it necessitates organizational adaptation while it punishes inertia, which – according to our mechanism – may help organizational adaptation. Conventional wisdom holds that inertia is punished more when environmental change is faster and greater, because less time is available for more substantial adaptation. It is therefore natural to expect that in a highly turbulent task environment (both in terms of the frequency and degree of turbulence), the negative effect of inertia would dominate the positive effect of the suggested mechanism. What is rather less trivial is whether the adaptation-fostering effect of the suggested mechanism would accumulate across the environmental regimes – organizations might build on what they have learned and developed prior to an environmental change. Our analysis suggests that the answer is "yes", and because of that, the effect of the suggested mechanism is more pronounced than would be expected in a turbulent task environment.

We operationalized the two dimensions of environmental change, frequency and size, by parameterizing the duration of a stable environmental regime and the number of routines that are influenced by an environmental change (i.e., altering a portion of the fitness landscape). Technically, upon an environmental change, the contribution values (w_i) of a number of randomly chosen routines are reset (to values drawn from the same uniform distribution). Figure 10 presents the results for the

four representative cases by frequency (environmental changes at every 300 periods vs. 100 periods) and size (the contribution values of 10% vs. 90% of the routines to be reset). Organizational fitness is measured at the end of each regime – for example, at the end of 300th, 600th and 900th time periods for the case of regimes of 300 time periods.

The results confirm the conventional wisdom that faster and larger environmental changes punish inertia more; that is, organizational adaptation is more limited for a higher value of *R*. Navigating through environmental regimes, however, the suggested mechanism pushes organizational adaptation forward and its positive effects accumulate and become pronounced. When the size of environmental change is relatively small (Figure 10a), for example, a higher level of routine inertia (e.g., *R*=0.9) eventually leads to a greater degree of organizational adaptation, even though the environment changes frequently. In empirical reality, however, it is not crystal clear how to define a big or small environmental change. What is labeled as a small change (shaking 10% of the landscape) in our model might be a big one in real-world contexts. Nevertheless, our simulation experiment and analysis help understand the interaction effects of the suggested mechanism and environmental change on organizational adaptation.

===== Figure 10 about here =====

Experiment 2: Organizational Adaptation with Endogenous Change of Routines

In the first experiment, we assumed that without external intervention (i.e., planned changes by top-down management), routines remain stable over time (*E*=0). This is our deliberate choice to help understand the suggested mechanism in a simpler setting. Now, we relax this assumption and bring endogenous change of routines into the picture. Technically, as specified in the model section, endogenous change occurs as follows. *In each time period, in addition to any planned change for the routine (which is implemented with a probability of 1-R), the state of a routine may also flip with a probability of E(1-R)*. Note that the consequence of endogenous change may, or may not, be beneficial at the organization level (again, we control for the effect of superior rationality or foresight), and the rate of endogenous change is also suppressed as much as the stability or inertia of

routines (R). Thereby, we formalize in a simple way the notion of endogenous change of routines as a source of organizational change as discussed in the routines literature (see the model section for more details), and examine its consequences for organizational adaptation. Second, in doing so, we explicitly show how the effect of the suggested mechanism is different and thus distinguishable from that of endogenous change of routines. The experiment setup is the same as in the first experiment except for the relaxed assumption of endogenous change of routines (i.e., E>0).

Figure 11 shows organizational fitness in the long run for different degrees of endogenous change (E) and routine inertia (R). The result suggests two important patterns. First, as discussed in the literature, endogenous change contributes to organizational adaptation. At low levels of E, regardless of R, an increase in E (more endogenous change) leads to a higher level of organizational adaptation. The mechanism behind this result is documented well. In complex task environments, additional variation (i.e., endogenous changes in addition to top-down, planned changes) helps get out of status quo traps caused by bounded rationality in search and therefore enhance organizational adaptation (e.g., Knudsen and Levinthal 2007, Levinthal 1997, Siggelkow and Rivkin 2005). Our result and the underlying mechanism are consistent with those of previous studies on the adaptive role of errors, or unintended (by top management) variations, in the process of organizational adaptation – e.g., ignorance of cross-divisional interdependences (Siggelkow and Rivkin 2005), incomplete architectural knowledge (Ethiraj and Levinthal 2004a), or evaluation errors (Knudsen and Levinthal 2007). Above a certain level, of course, endogenous change of routines could be detrimental to organizational adaptation because excess endogenous change can counteract or destabilize organization-wide coordination – e.g., due to the agency problem, violation of standard rules, inappropriate improvisation or mistakes.

===== Figure 11 about here =====

Secondly, and more importantly, inertia in routines not only resists negative effects associated with destabilizing or uncoordinated endogenous changes (stability effect) as assumed in the model setup for the rate of endogenous change, $E(1-R)$, but also contributes to organizational variation and adaptation (exploration effect) as discussed in the first experiment. That is, the highest level of

organizational adaptation that could be achieved with R=0.9 is greater than the highest level of organizational adaptation that could be achieved with R=0 or 0.5. This implies that the suggested mechanism in the first experiment works in parallel with the effect of endogenous change of routines; that is, the two mechanisms are different (they take place in different dimensions). Therefore, both the stability/inertia and endogenous change of routines could contribute to organizational adaptation.

DISCUSSION AND CONCLUSION

In this study, we examine the implications of routine dynamics for organizational adaptation. With a formal model of an organization as a configuration of interdependent routines, we analyze how the stability/inertia and endogenous change of routines influence the process of organizational adaptation driven by top management characterized by bounded rationality. In particular, we scrutinize the conventional wisdom that routine-level inertia, as a byproduct of stability, slows down organizational change and hinders organizational adaptation. Based on the results of our simulation experiments, we point to an overlooked mechanism by which inertia in routines helps, rather than hinders, organizational adaptation by engendering the potential for exploration – temporal reordering of planned changes at the routine-level. The proposed mechanism highlights a complementarity between inertia in routines and the bounded rationality of agents – more generally speaking, a complementarity between the limits to the rate of change of organizational structure and the limits to the ability of individuals to figure out desirable change. Prior research has already identified some other complementarities – e.g., routines can free up cognitive resources that can be directed to particularly valuable purposes (e.g., Bigley and Roberts 2001, Levinthal and Rerup 2006, Weick and Roberts 1993). Yet, the proposed mechanism has not received much attention in the literature, even though both of its elements, bounds to cognitive resources (and foresight) and the inertial tendency of routines, are strong empirical regularities (Cyert and March 1963, Gilbert 2005, Hannan and Freeman 1984, 1989, Nelson and Winter 1982, Padgett 1980, Simon 1947).

Novelty of the Mechanism: Inertia as a Source of Variation

As regards the novelty of the proposed mechanism, the *source* of variation, which facilitates

organizational exploration, is noteworthy. Previous studies on organizational search and learning have identified several mechanisms by which organizations engage in broad search to overcome exploitation traps in complex task environments. Most of these mechanisms, however, rely on change efforts with errors such as incomplete architectural knowledge (Ethiraj and Levinthal 2004a), ignorance of cross-divisional interdependences (Siggelkow and Rivkin 2005), or imperfect evaluation of alternatives (Knudsen and Levinthal 2007). In the adaptation processes that are examined in those studies, planned changes can be detrimental as well as beneficial to the organization – for instance, a beneficial change to a group or department could be planned even though it is detrimental at the organization level. In contrast, in our model setup, to control for such alternative mechanisms, a change is planned *only if* it benefits the organization by improving organizational fit with the task environment. What generates additional variation is rather inertia in routines, which in prior literature has been known to reduce variability while enhancing stability. Inertial routines, as the target of change, apparently slow down organizational adaptation that involves changes to the routines. This is the well-known consequence of routines as a source of organizational inertia. Our study, however, suggests that there is a hidden role of inertia in routines as a source of organizational variation: A reduced rate of change at the routine level may cause variations in the pace and sequence with which planned changes to the routines and their effects take place, and such reordering of the planned changes may open the door to further organizational exploration and adaptation.

In this regard, the stability or inertia of routines not only produces aggregate effects in terms of organizational stability or inertia, but also aids in organizational adaptation. Our mechanism therefore works on a different dimension than the mechanisms identified in prior research (as discussed in the theory section) where the stability of routines takes a backseat and only supports the efforts to promote change – such as recombination, exploration, experimentation or improvisation – by providing stable building blocks, freeing up cognitive resources, or allowing for systematic/stable approach to change (see Table 1 for a comparative summary). This implies that the proposed mechanism complements, rather than counteracts, the role of other mechanisms identified in previous studies on routines and on organizational adaptation.

===== Table 1 about here =====

As such, our mechanism contributes to resolving the stability-change dilemma by unpacking the dynamics residing between different organizational levels. We confirm the conventional wisdom that inertia in routines, as a byproduct of stability, resists planned changes to the routines and thus slows down organizational adaptation. We shed light, however, on (unanticipated) temporal reordering of the planned changes, an overlooked consequence of reduced rates of routine-level changes, which facilitates organizational exploration and learning. In other words, the proposed mechanism sheds light on an overlooked effect of routine-induced inertia that influences the *scope* of organizational search, while other discussions of routine-induced inertia have been focused on the *speed* of organizational change. To the best of our knowledge, the mechanism we identify has not yet been (un)covered in extant literature on organizational learning/adaptation.

It is also noteworthy that the proposed mechanism is different from, but associated with, the well-known idea of recombining stable building blocks of routines. The latter relies on deliberate choices and planned actions to mix and match available routines in response to environmental conditions. In contrast, the suggested mechanism does not necessarily involve intended changes to the set of routines – i.e., addition, deletion or reconnection of routines, such as in business process reengineering (BPR). Rather, the idea of reordering planned changes relies on the *unintended*, unforeseen variations in the process of implementing the intended changes to the existing routines – unintended recombination of planned "changes" as compared to intended recombination of available routines. This implies that the two mechanisms may work in parallel on different dimensions, so the organization may benefit both from the variation generated in the process of selecting among available routines, and from the variation generated in the process of modifying (i.e., planning and implementing changes to) the selected ones. One may find that this goes parallel with the distinction between architectural change and module development (Baldwin and Clark 2000, Sanchez and Mahoney 1996); that is, there is room for variation both at the architecture level and at the module level, and they may jointly contribute to organizational adaptation (Ethiraj and Levinthal 2004a). What we highlight in this study is that the stability of routines, serving as a reliable basis for flexible

recombination (Nelson and Winter 1982) or organizational learning (Levinthal and March 1993), may not only slow down subsequent modifications of the recombined routines (i.e., the inertia issue), but also engender additional variations useful in the adaptation process.

In addition, note that we do not assume that organizations have some kind of adaptive capability that allows them to change the way they make decisions regarding the state of operational routines (or the overall configuration of such routines). In other words, we assume stability of the decision-making process in which alternative changes to the routines are suggested, evaluated and planned – i.e., we assume stability of 'meta routines' or 'modification routines' (Levitt and March 1988:321, Nelson and Winter 1982:17). Although changes to the way of decision-making (or to the decision makers) can happen in reality, we controlled for such a possibility as an alternative mechanism of variation – the way decisions are made (i.e., local search) is fixed in the model. In doing so, we demonstrate in a simple model setup that inertia in the routines used for decision making may counteract and help overcome the liability of inertia in the operational routines. An illustrative example would be Burgelman's (1994) account of how inertial forces in decision making (i.e., the heuristics to maximize the economic value of a semiconductor wafer) enabled Intel to make adaptive resource allocation toward the emerging microprocessor business, diverging from the basis of its competitive advantage in the memory business and the strategic actions taken by its middle managers. In this regard, our results imply that inertia at different levels or places of an organization may interact with each other to help organizational adaptation.

Managing Routines for Balancing Stability and Change

Our mechanism provides practical implications for managing routines to achieve organizational stability and change. As reflected in Levinthal and March's (1993: 105) idea of 'learning trap', organizations can become "trapped in one or more of several dynamics of learning that self-destructively lead to excessive exploration or excessive exploitation." In other words, there is also a risk of over-exploration, i.e., keep changing without reasonable rewards. Prior research, such as Amburgey (1993: 54), has noted this, calling it 'another form of inertia (momentum)': "The more experience an organization has with a particular type of change, the more likely that the change will

be seen as a solution to a broader and broader set of problems." Practices such as a "flavor of the month" approach to change (constantly making small changes that appear to be improvements) can trigger excessive exploration and the related costs.

Our mechanism suggests that routines can play a role in balancing stability and change, reducing the risk of excessive exploration. In experiment 2, we demonstrated such a role of routines as a source of stability for high values of *E* (i.e., suppressing or counteracting too much variation made without sufficient coordination at the organization level). That is, efforts to develop routines to accomplish demanded tasks in a repeatable and reliable manner, despite increasing inertia (slow adaptation), may also contribute to balancing stability and change – or in terms of March (1991), to balancing exploitation and exploration. What is more readily observable in actual practice might be delay and inertia. However, we should not ignore the consequences of inertia (e.g., generation of variation and triggering of subsequent exploration), which may accumulate in the organization over time and eventually contribute to observable organizational adaptation and success.

Routines and the Theory of Economic Evolution

Our theory contributes to the internal consistency of the evolutionary economics program, which highlights the stability of routines as a quasi-genetic trait (Nelson and Winter 1982). The notion of a routine is a fundamental construct in the evolutionary economics program, and it is therefore important to explain in an evolution-friendly way how the emergence and persistence of stability or inertia could be an essential feature of routines. That is, inertial routines should somehow provide organizations with an evolutionary advantage in the process of their adaptation or environmental selection. Considering the bounded rationality of decision makers, and highlighting the adaptive role of routines, our theory explains this in terms of both adaptation and selection. That is, inertia in routines not only results because organizational stability, or reliability (i.e., low variance in behavior and performance), has an advantage in selection processes (Hannan and Freeman 1984, Levinthal and Posen 2007), but may also be favored because it facilitates organizational adaptation in task environments characterized by complexity and uncertainty.

This logic is an important key to understanding the performance of organizations (e.g., large and old ones) that look inertial, but keep surviving, and from time to time exhibit outstanding performance (Adler and Borys 1996, Carroll and Hannan 2000, Levinthal and Posen 2007). In a similar manner, the logic also helps better explain the emergence and persistence of inertia in a population of organizations (Hannan and Freeman 1984) through both adaptation and selection: inertia that emerges as a byproduct of selection (due to preference for or survival advantage of low variance in behavior and performance) may also help in adaptation. As such, the suggested mechanism contributes to our understanding of how adaptation and selection can act as "complementary" forces that jointly drive economic evolution. In this regard, the proposed mechanism does not undermine the foundation of the theory of organizational ecology (Carroll and Hannan 2000, Hannan and Freeman 1984), but rather provides useful insights that can advance the ecological research program in connection with research on routines and organizational learning/adaptation. We think that at the core of such a research program is the understanding of how routines are involved in and contribute to the interplay between organizational adaptation and environmental selection.

From the perspective above, organizations have incentives and tendencies to develop in the direction in which their activities are formalized and routinized (Adler and Borys 1996). This direction of organizational adaptation in turn helps selection forces to work in a way that stimulates the evolution of the organizational population as a whole. Therefore, the level of inertia can be 'selected' as a force that drives population-level adaptation. At the heart of this logic lies the causal link that inertia in routines can help organizational adaptation, or more generally speaking, that inertia is not only a consequence of selection, but also a source of variation and adaptation.

Future Research

Our theory highlights promising opportunities for future research. The conditions where (routine-engendered) stability, or inertia, provides more or less advantage can be further examined along the lines proposed here. At the most fundamental level, we need empirical research that systematically examines inertia in routines (as a byproduct of stability and reliability) and its consequences (for, e.g.,

exploration, learning and adaptation) in connection with bounded rationality of the management. It is further interesting to examine how different environmental or organizational factors could moderate or condition the effects of routinization and inertia on organizational reliability, adaptation and survival. Important factors might include the elements of organization design, the nature of industry structure and competition, the degree of environmental or technological change, and the effects of entry/exit or entrepreneurship. We hope our model and theory serve as a useful basis in this endeavor.

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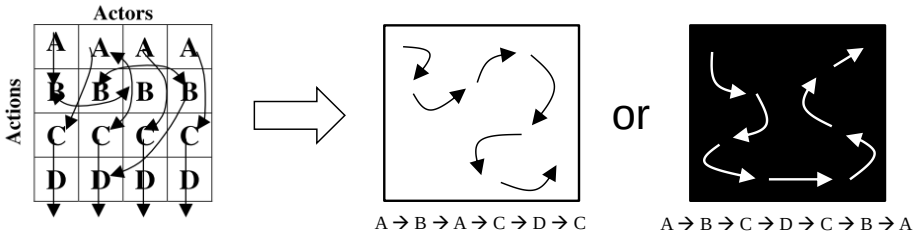
Figure 1. Illustration of the Model

Representation of a Routine



Pentland (2003b: 531)

Model Procedure in Each Period ($N = 5$)

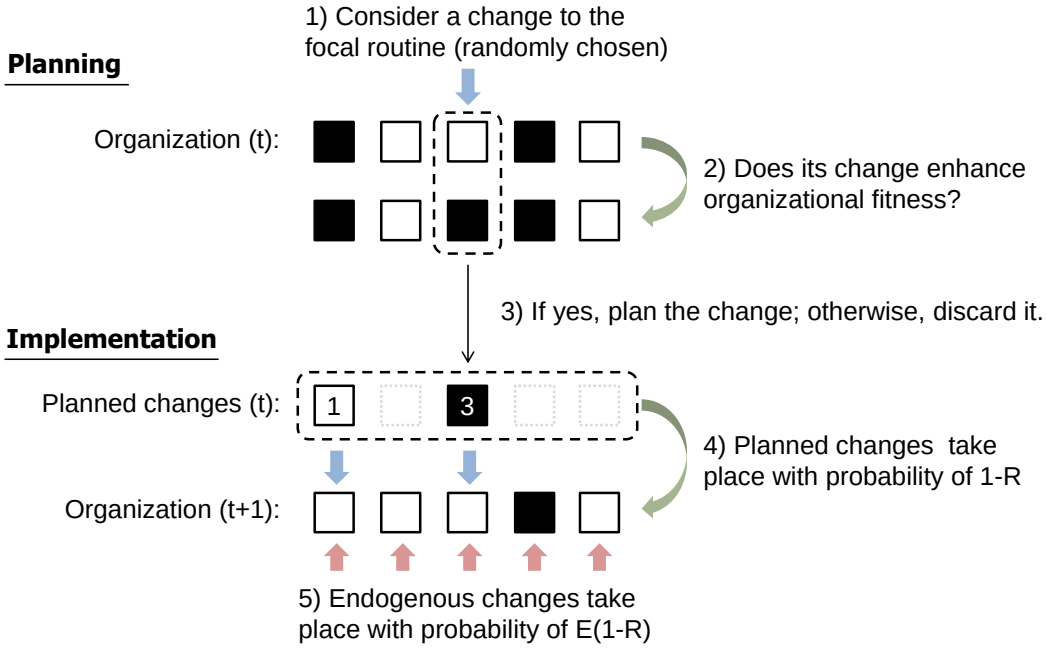


Figure 2. Effects of Inertia in Routines (*R*) on Organizational Adaptation (*N*=10, *K*=3)

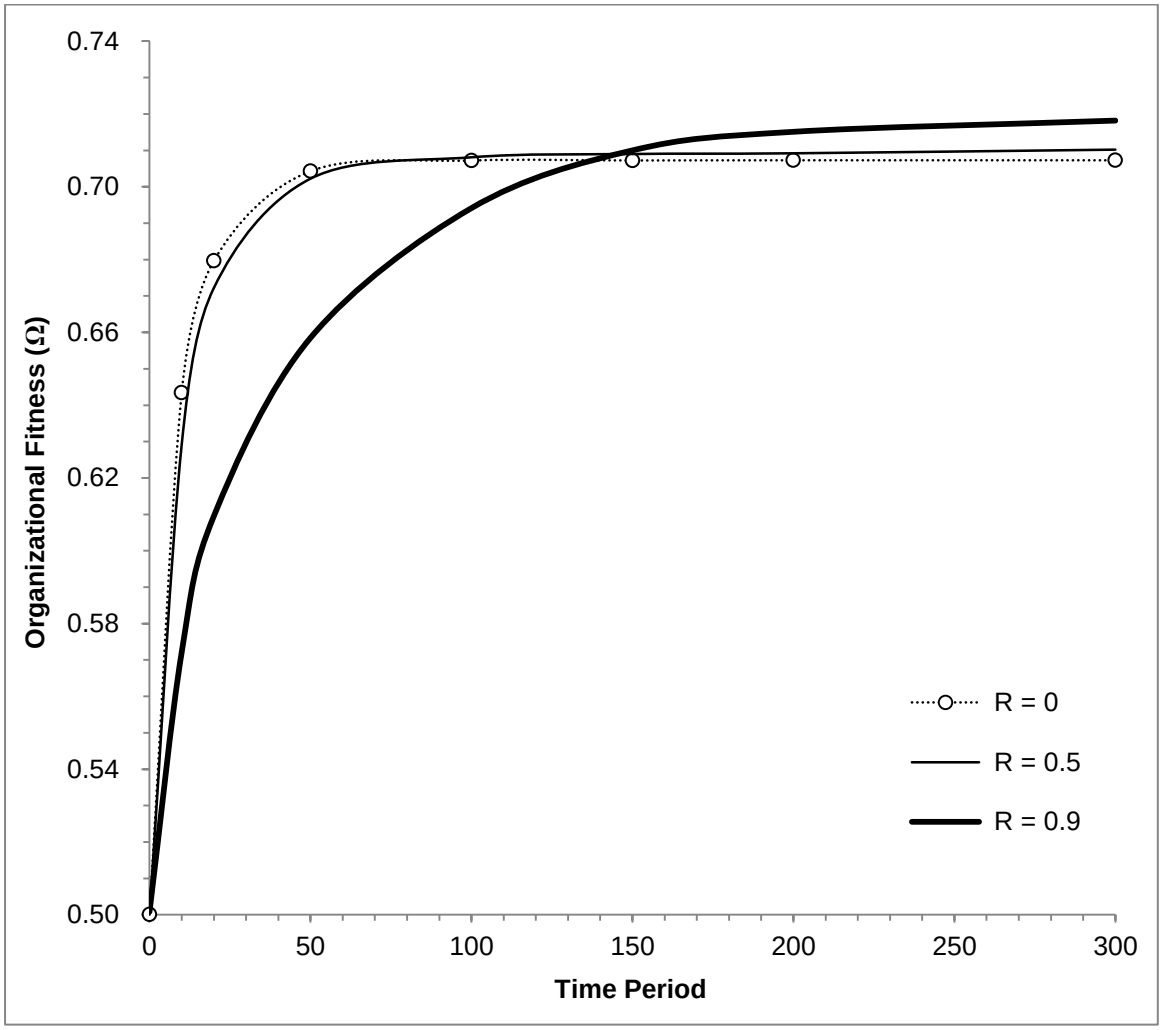


Figure 3. Effects of Inertia in Routines (*R*) on Organizational Change

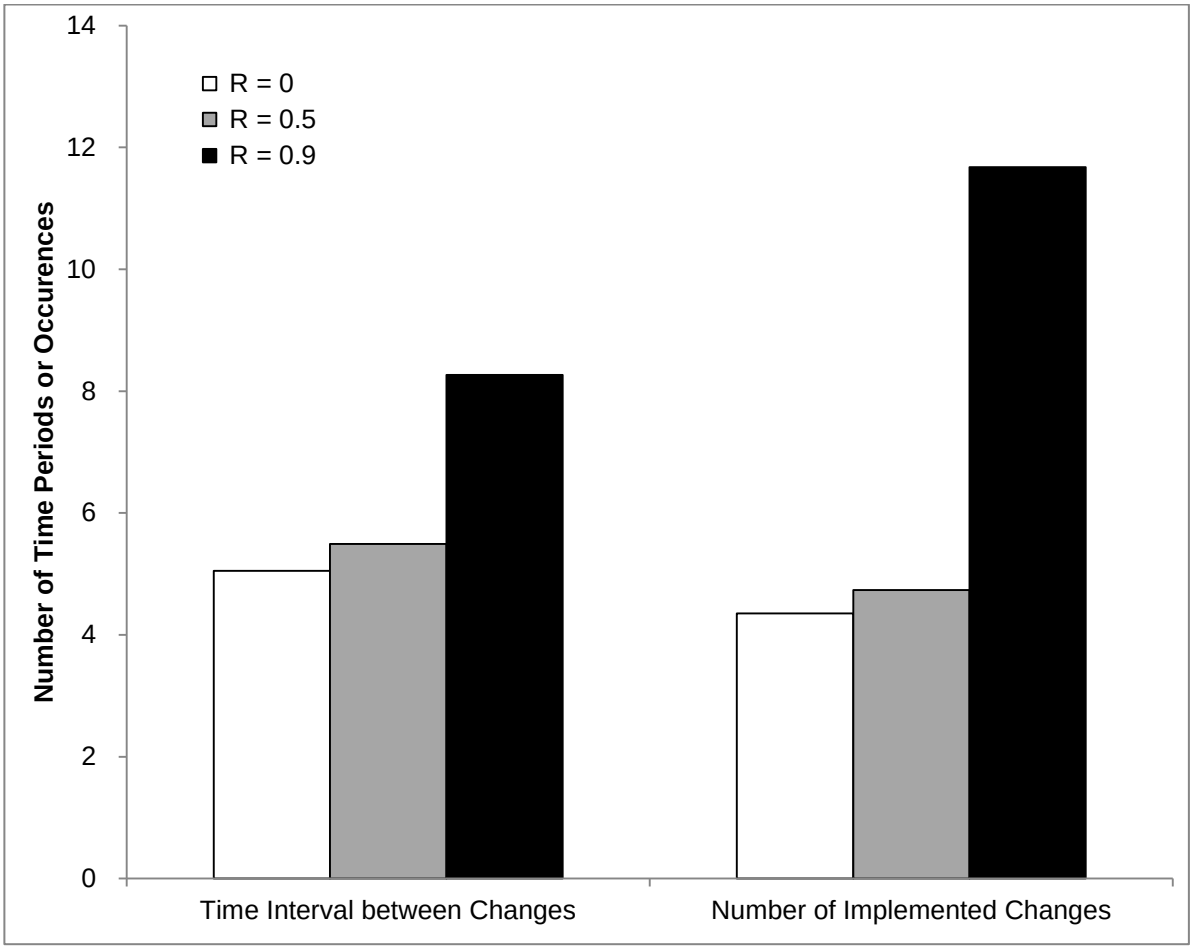


Figure 4. Illustration of the Mechanism

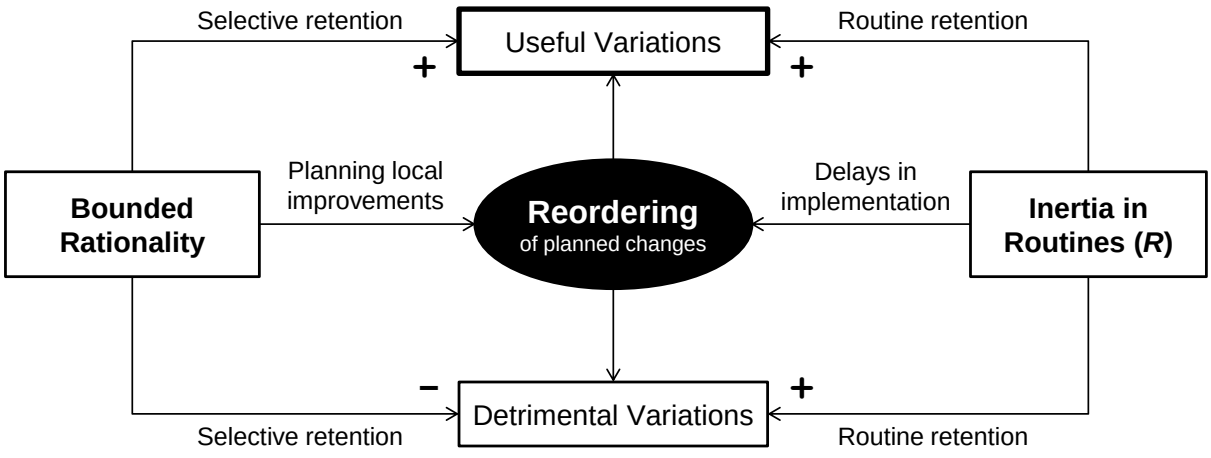
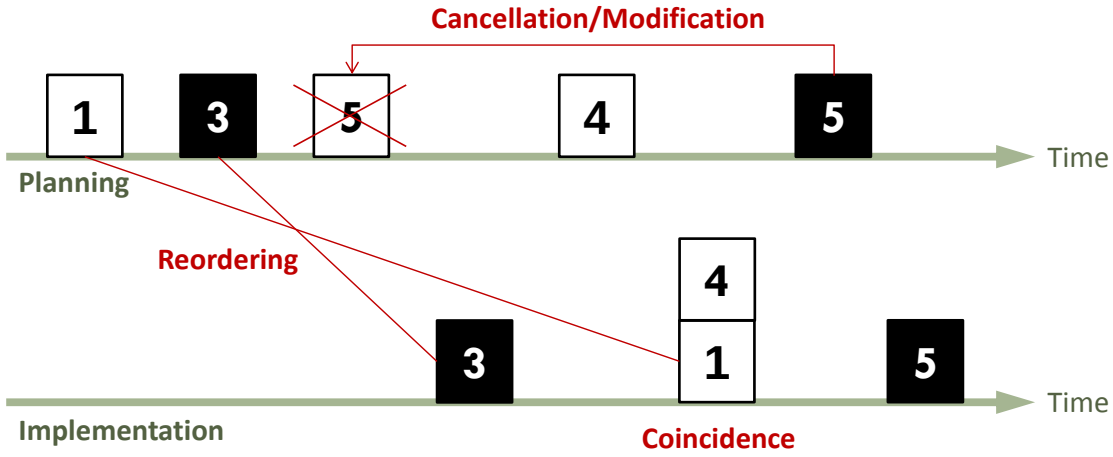


Figure 5. Unplanned Variations in the Process of Implementation of Planned Changes



Note: Each black or white box on the 'Planning' line represents a planned "change" to the corresponding routine indicated by the number inside the box. For instance, the white box with number 1 denotes a change of the first routine to the state of 0, and the black box with number 3 denotes a change of the third routine to the state of 1. In the hiring example (used to explain the mechanism in experiment 1), the white box 1 and the black box 3 would correspond to the two planned changes, centralizing the screening of applications for different parts of the organization, and requiring strict accordance of application documents with regulations, respectively. The locations of the boxes on the line indicate the points in time when they were planned. The boxes on the 'Implementation' line show when the planned changes were actually implemented so that their effects materialize and can have consequences for subsequent decision-making and adaptation. By coincidence, routines #1 and #4 happen to be implemented simultaneously.

Figure 6. Decomposition of the Unplanned Variations

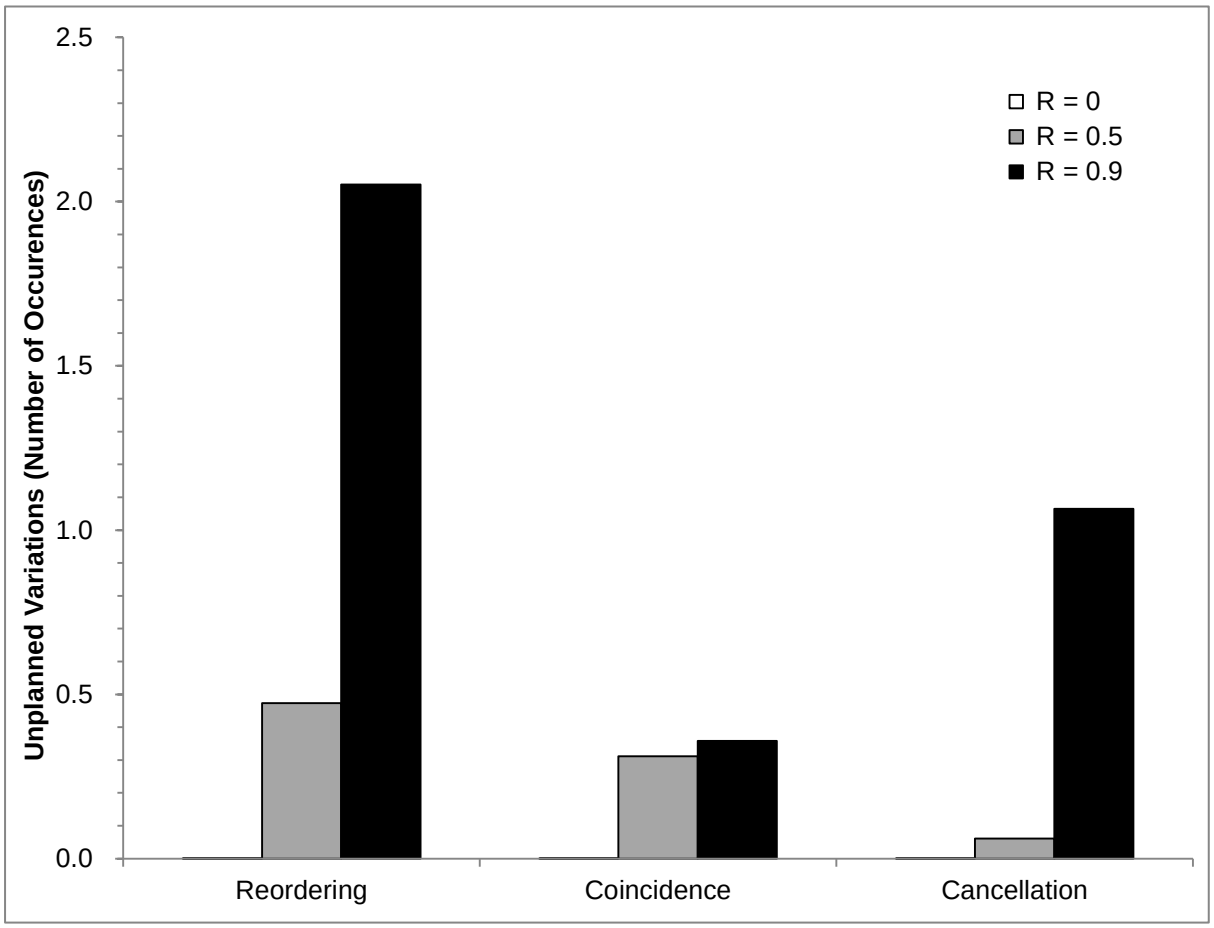


Figure 7. Effects of Organization Size (*N*) on Organizational Adaptation (*K*=3)

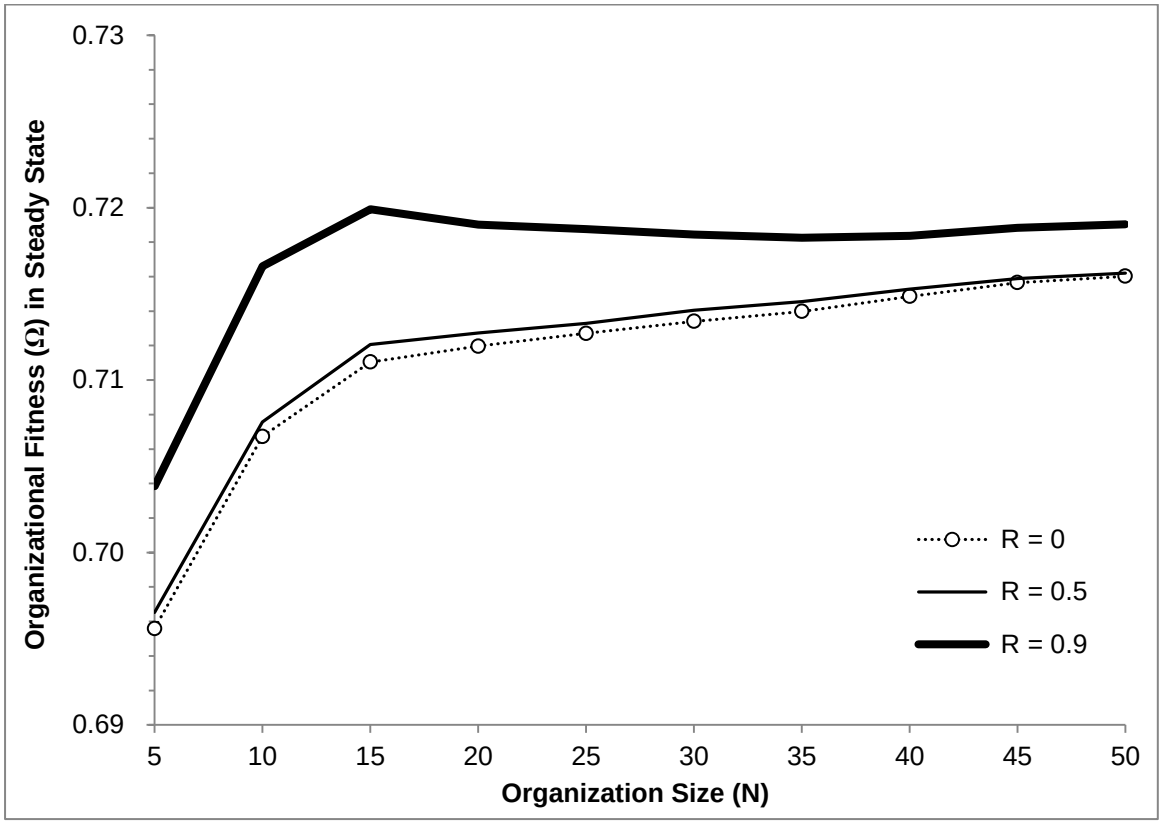


Figure 8. Effects of Interdependence among Routines (*K*) on Organizational Adaptation (*N*=10)

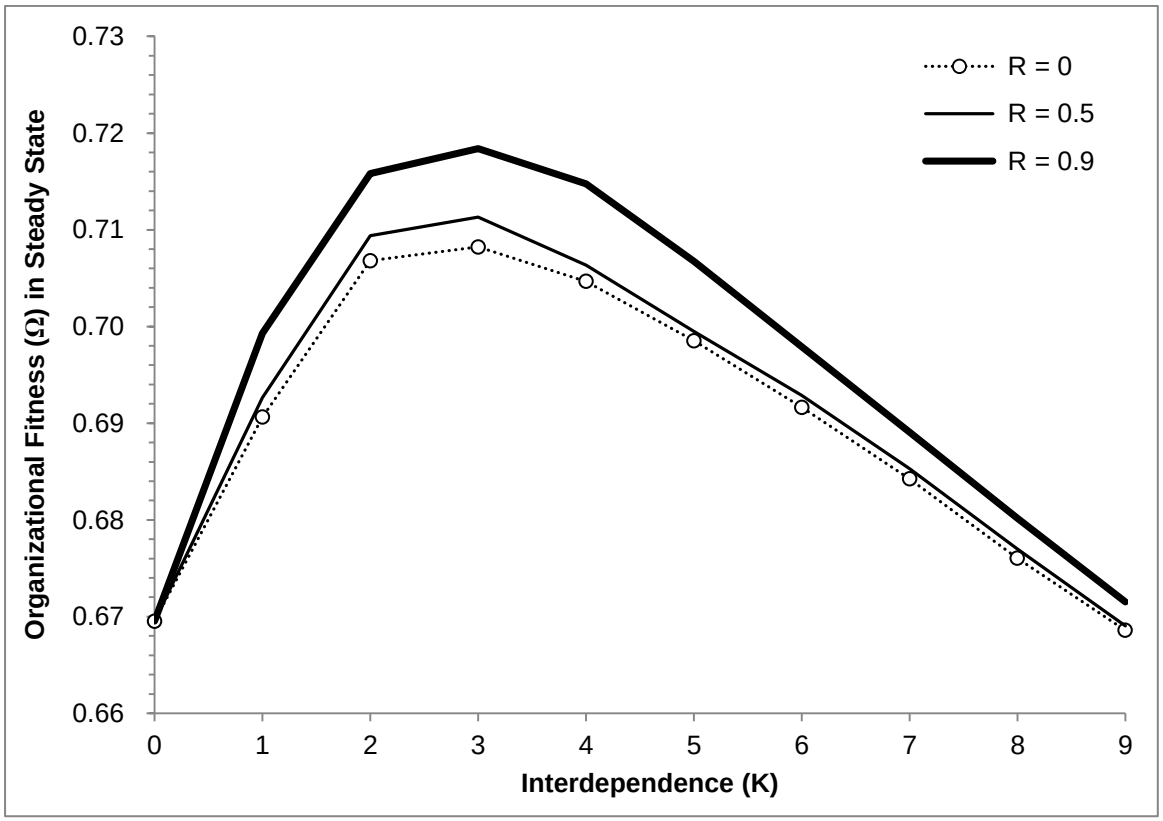


Figure 9. Effects of Core Rigidity (*G*) on Organizational Adaptation (*N*=10, *K*=3)

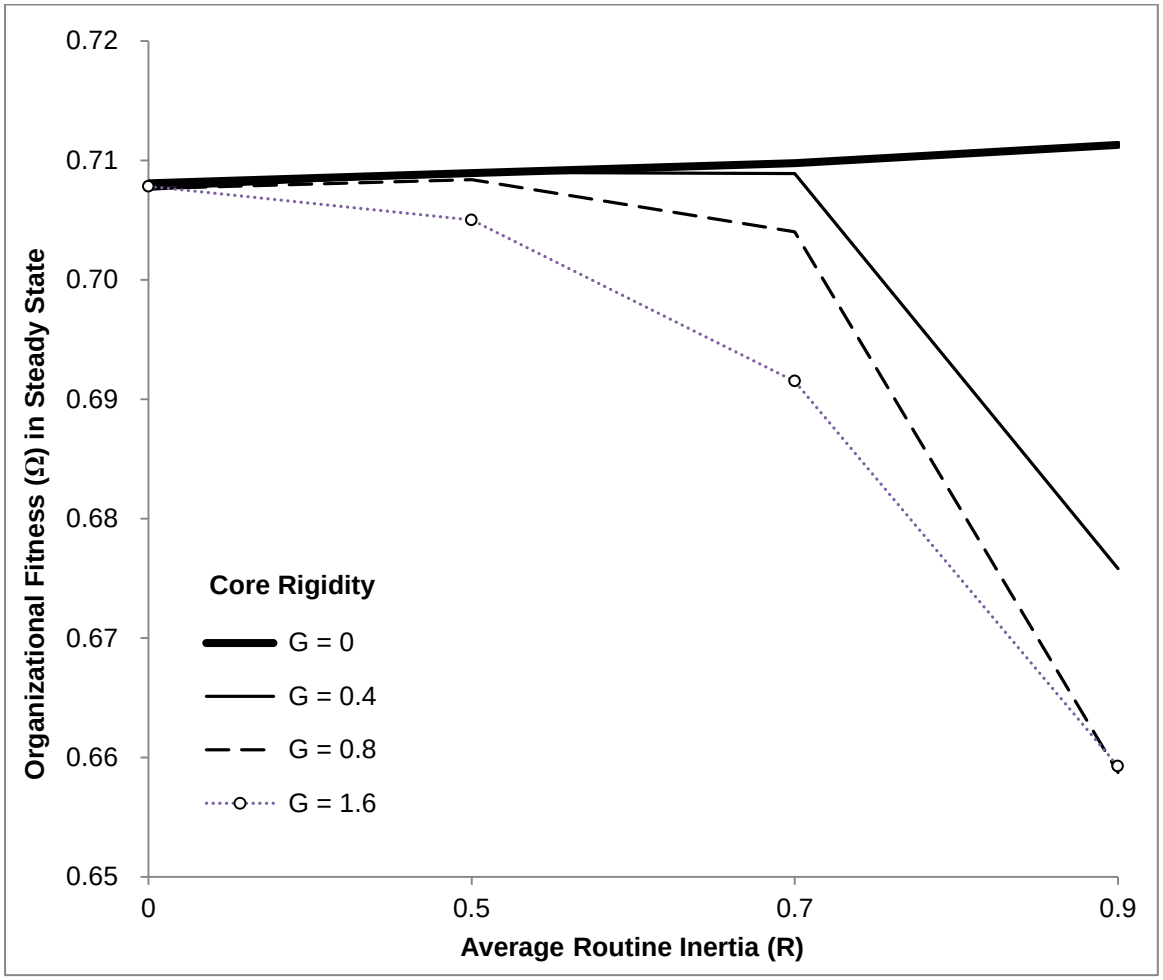
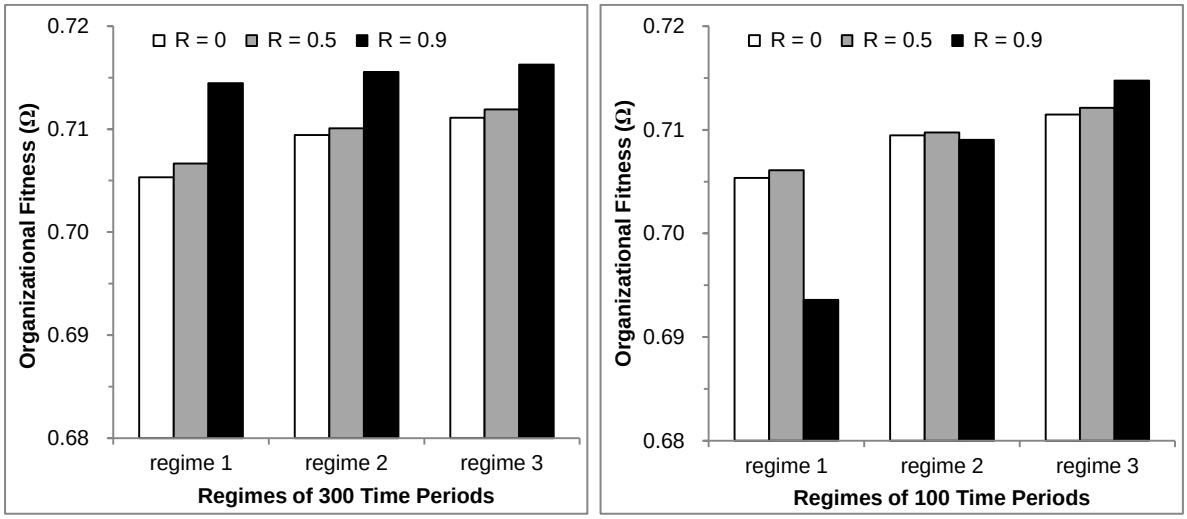


Figure 10. Organizational Adaptation in a Volatile Task Environment (N=10, K=3)

(a) Small environmental changes (resetting 10% of the landscape)



(b) Large environmental changes (resetting 90% of the landscape)

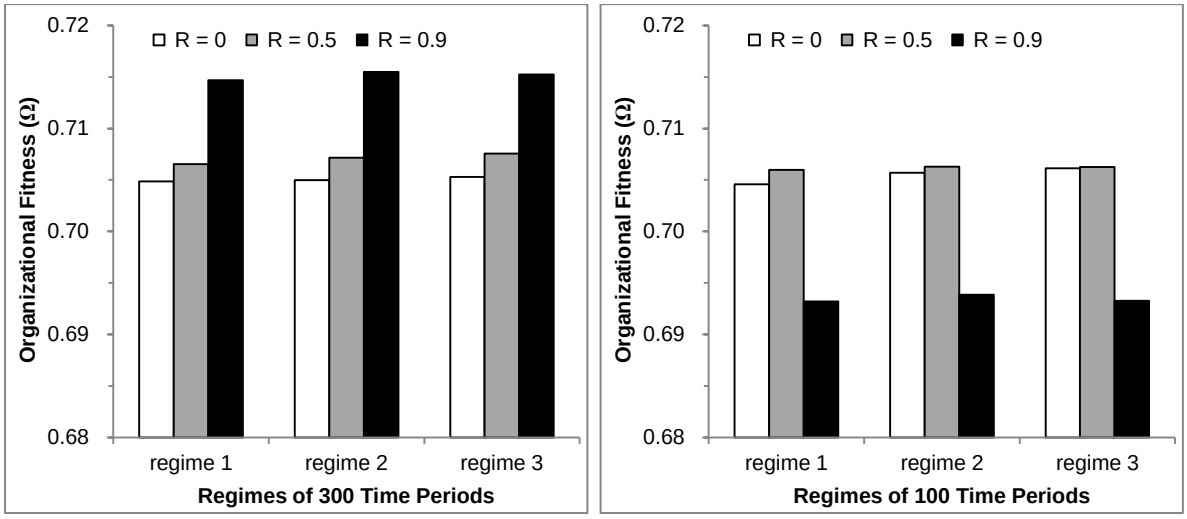


Figure 11. Effects of Endogenous Change of Routines on Organizational Adaptation (N=10, K=3)

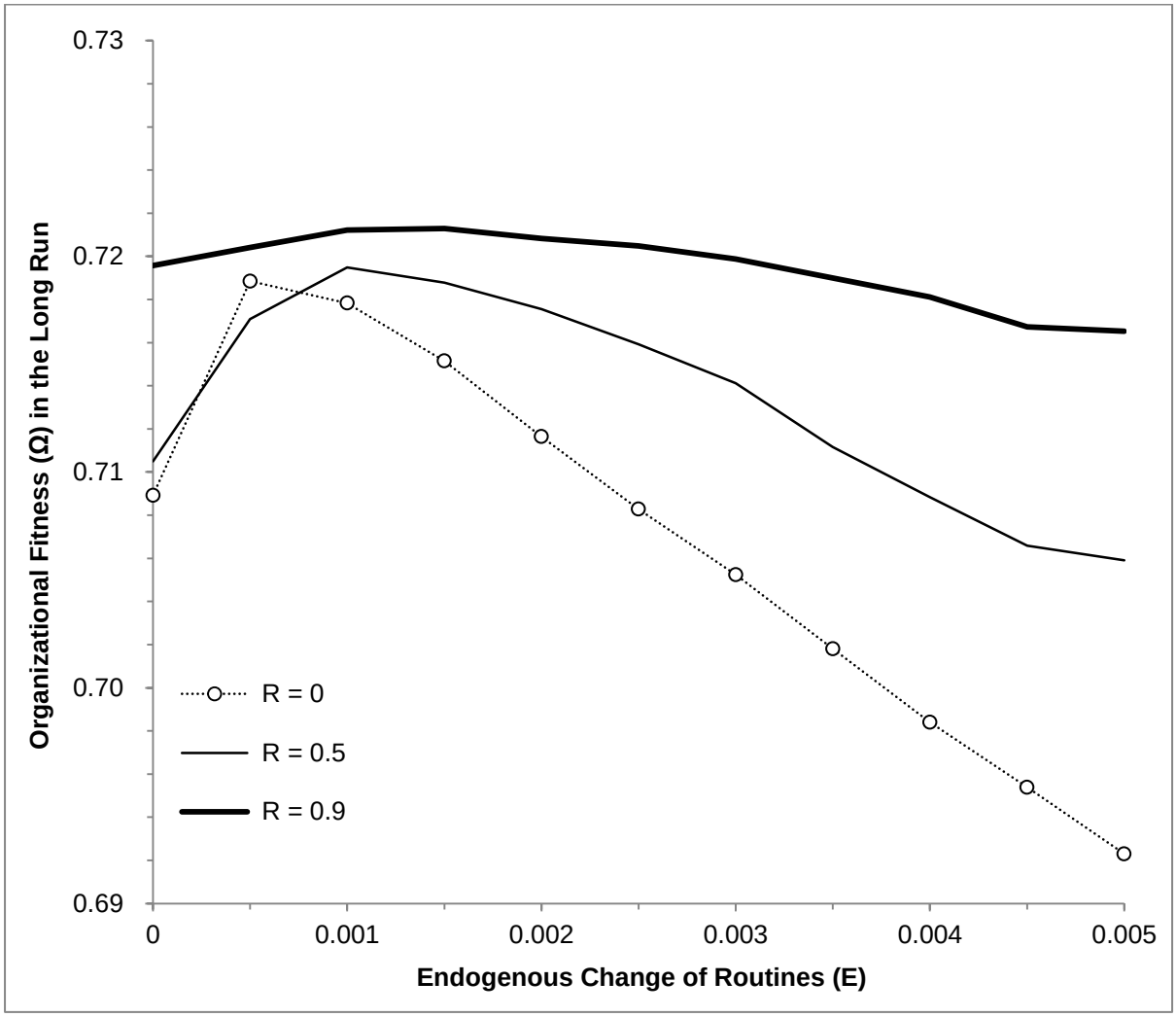


Table 1. Mechanisms by which Routines Help Organizational Adaptation

Mechanisms	Source of Variation	Source of Adaptation	Role of Routines
Recombination of Routines	Planned (coordinated) recombination by agents	(Bounded) rationality in variation	Supporting variation by serving as stable building blocks
Routinizing Change-Tasks (Exploration)	Planned (coordinated) changes by agents	(Bounded) rationality in variation	Supporting variation by systemizing/stabilizing efforts for change
Routinizing Resource Allocation	Planned (coordinated) changes or resource re-allocation by agents	(Bounded) rationality in variation	Supporting variation by promoting/stabilizing efforts for change
Endogenous Change of Routines	Unplanned and/or uncoordinated changes by routine participants	(Bounded) rationality in variation	Generating routine-level variation in the process of performance
Proposed Mechanism	Unintended reordering of planned, coordinated routine-level changes due to inertia in routines	Bounded rationality in selective retention	Generating organization-level variation by reducing rate of routine-level change