THEORIES OF ORGANIZATIONAL CHANGE: A SYSTEM DYNAMICS PERSPECTIVE

by

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Submitted to the Alfred P. Sloan School of Management
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ABSTRACT

The ability for organizations to change has become more important recently, as the pace at which technological and competitive environments change quickens. In this thesis, I explore three classical organizational change theories using a systems dynamics framework. The theories explored are representative of the population ecology, rational adaptation, and punctuated equilibrium theories. By applying a system dynamics framework to the theories, causal loop structures and modes of behavior over time are identified. The framework allows a direct comparison of key concepts, structure, and behavior. The behavior posited by the theories is varied, and found to be caused primarily by the authors' choice of boundary and structure. Issues explored include types of change, organizational and environmental uncertainty, competency, resource accounting, organizational inertia, and goal adjustment.

Thesis Supervisor: John D. Sterman
Title: Professor of Management Science
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1 INTRODUCTION

This thesis attempts to develop a general framework with which to explore formalized theories from a systems perspective, and apply this framework to three theories of organizational change. These theories are representative of widely read, albeit different, theories of organizational change: population ecology, (Hannan and Freeman 1977, DiMaggio and Powell 1983) punctuated equilibrium, (Gersick 1991, Tushman and Anderson 1986, Tushman, Newman, and Romanelli 1986) and rational adaptation (March and Simon 1958, Simon 1979). Although my initial intent was to focus on simulation-based works on these theories, the chosen works have different levels of formalization. The first theory, while providing a framework, did not provide an accompanying analysis. Complete models were presented in the second and third theories.

A system dynamics perspective provides tools to inspect the underlying structure of these theories. Although traditionally unstructured theories have been developed in the field of organizational behavior, more theorists have begun to apply analytical tools to explore this field. (Starbuck 1983, Mezias and Glynn 1993, Sastry 1994) I have found that the process of understanding the underlying structure of a theory offers new understanding into the theories put forth. In addition, applying a single framework to multiple theories allows one to understand a theory in the context of the field.

The application of a systems framework in this work demonstrates how the choice of scope, and the structural differences in the theories account for wide variation in posited behavior. It is interesting to note that very few of the assumptions made in these three theories are in direct conflict with one another. Rather the choice of what to include in the analyses differed. It is possible that many or all the forces identified in these theories are important determinants of behavior, but their relative strengths may vary from one situation to another.

In section 2, I explore why understanding organizational change is important. Section 3 introduces and explains the system dynamics framework that will be used in the analysis. In sections 4, 5, and 6, I employ the framework to explore the three theories of organizational change. These works were created using very different methodologies, which generated some differences in the way in which I
applied the framework. For instance, the population ecology theory had little formal analysis in the published work which made the analysis subject to judgment. The authors did identify their assumptions and conclusions explicitly, which I simply repeat. In the rational adaptation theory, a detailed model was presented which made identifying the boundary and structure easier. However, the authors did not explicitly identify their assumptions. The third theory on punctuated equilibrium was modeled using system dynamics. This simplified my analysis.

After analyzing each of the theories independently, in Section 7, I compare their posited concepts, structures, and behaviors to highlight areas of contention, agreement, and ambiguity. Section 7 also contains some process reflections for this work.
2 WHY ORGANIZATIONAL CHANGE THEORIES?

While many in industry and academia have identified a need for organizations to be able to adapt to their often rapidly changing environment, there is no consensus on the underlying forces affecting the ability of organizations to successfully plan and implement change. These issues continue to challenge managers who, without a thorough understanding of organizational change, have difficulty assessing and mitigating the risks of planning and implementing change. It is my hope to further clarify the understanding of three popular theories of organizational change, as a first step to identifying forces that motivate and prevent organizational change.

The three analyses that are examined in this paper are: Michael T. Hannan and John Freeman's "Structural Inertia and Organizational Change", Daniel Levinthal and James G. March's "A Model of Adaptive Organizational Search", and an analytical work by M. Anjali Sastry (1994), based on Tushman and Romanelli's "Organizational Evolution: A Metamorphosis Model of Convergence and Reorientation".

3 A SYSTEM DYNAMICS PERSPECTIVE

In the past several decades, organizational theorists have begun to perform analyses using more formal modeling tools. In that vein, I believe that system dynamics methods can provide an important contribution to the understanding of the existing theories by highlighting less conventional feedback perspectives. Indeed, feedback processes have already been noted by some organizational theorists. (Masuch 1985, March 1988 )

When trying to understand the many theories of organizational change, it is useful to use a single framework. By using a general approach to understand organizational theories, commonalities and differences become easier to identify. While the system dynamics framework is not purported to be the single best way to analyze theories, it does provide an approach that complements the existing methods of analysis. System dynamics provide tools to determine causes of behavior observed over time of many different variables. It focuses on the causal relationships between concepts (e.g. An increase in the number of eggs will cause
an increase in the number of chickens), as well as the often overlooked feedback loops in situations (... which will cause an increase in the number of eggs). By exploring the underlying causal structure of a situation, the behavior of the concepts in that structure can be deduced. Finally, because the human mind is limited in its capacity to simultaneously keep track of multiple dynamic variables, formal modeling is often necessary.

By making explicit the causal relationships in a theory, it becomes easier to understand the proposed underlying structure. Causal structure diagrams also help to identify potential sources of feedback which can have effects that are often counter-intuitive. Structure diagrams complement written descriptions by enhancing the readers' understanding of the theory, and integrating the system of relationships described.

After identifying the posited feedback loops in a structural diagram, the consistency between posited behavior over time and the underlying structure can be examined. It is important to note that while developing the structural diagrams provides new insights, complex structures may not be fully understood without formal modeling. An experienced modeler may develop intuition about the behavior of simple feedback loop structures, but in most cases the process of building a detailed model provides more (often counter-intuitive) insights into the proposed structure. However, detailed models will not be presented in this work, but are left for future research.

The system dynamics perspective used in this work provides most of the benefits noted above. This framework was adapted from frameworks derived by others, including Sterman (1988), Meadows and Robinson (1985), and Hall (1976). The system dynamics framework comprises a checklist of questions about the following concepts:

- Purpose
- Boundary
- Type of Analysis
- Key Concepts
- Data, Robustness and Testing
- Causal Relationships and Structure
- Timing
Assumptions
Behavior and Conclusions
Documentation and Reproducibility
Omissions

These aspects of each of the three theories will be studied. The structure of the framework is formed as a series of questions. The answers to these questions help to paint a picture of the entire theory and its structure, which augment other methods of analysis. These questions are not complex, and are reasonable to ask of a formal theorist. However, only the published works will be used to derive answers.

3.1 Purpose

What is the purpose of the analysis? Who funded the research?

The purpose of a particular analysis is something that should not be overlooked. Although theorists usually make an effort to represent the world objectively, there is an unavoidable perspective in the final product. Intellectual investment in a given viewpoint is difficult to escape.

The entity that funded the research should be identified, as well as their intellectual investment in the theory. Although information on the funding institution is often available, the underlying expectation is rarely stated in the published work.

3.2 Boundary

What concepts and effects have been included in the analysis? Are concepts included as exogenous inputs? Are the causally related forces included for these concepts? On what level is the analysis done?

It is necessary to note what effects have been included in a theory, and it is instructive to note what effects have not been included. For this reason, a simple boundary diagram categorizing concepts and issues as endogenous, exogenous, or omitted.
Endogenous concepts are those whose behaviors are fully explained or defined by other concepts in the structure. The behavior of other variables inside the model determine the behavior of an endogenous concept.

Exogenous concepts are not controlled by internal model behavior, but are defined by external factors that are not included in the structure. They do have an effect on the behavior of other variables in the model.

Omitted concepts do not appear at all in the model. These concepts are completely omitted. Although there may be an implicit assumption that these variables have little effect on the behavior of interest, they may be omitted because it would make the model more difficult to understand, there is little data available, time constraints, etc. It is important to note any omitted concepts that could have significant effects on the behavior of the model. Although the effects may not be identified with certainty, noting them helps to put the theory in perspective.

The level of analysis is varies for many organizational theories. Typically organizational theories focus on the individual, group, organizational, or environment levels.

3.3 Type of Analysis

What formal methods are used to analyze the theory? Is a model designed, built, and/or presented? Are simulation methods used? Are analytical methods used? Is the model deterministic? Does it incorporate stochastic components? Does it incorporate feedback processes?

The models explored in this paper use different analysis methods. Some are more formal than others. This framework can be applied to works using different approaches. By applying this system dynamics framework, the first steps are taken to design dynamic feedback models of the theories.

3.4 Key Concepts

What specific ideas does the author use to explain the theory? What does the author convey about the definition of these ideas? Are they similar to ideas presented in other theories? Are soft variables included in the analysis?
Each theory has its own vocabulary. I identify concepts central to the authors' theory, and attempt to define them in terms of general concepts. I also cross-reference similar concepts from other theories to establish a common frame of reference for all the theories being examined. Identifying and operationalizing concepts help to develop a single vocabulary that can be used to discuss multiple theories.

3.5 Data, Robustness and Testing

Has the analysis been tested with data? Is there sufficient data demonstrating the behavior described? Does the posited behavior makes sense if the policies and parameters are varied over their feasible ranges?

In order to determine whether the posited theory is representative of reality, it is necessary to compare posited behavior of organizations to the actual behavior of organizations. Historically, it has been difficult for organizational theorists to gather statistically valid data. Many of the concepts that interest organizational theorists are qualitative, and cannot be measured directly. Also, much of the data is anecdotal, and not complete. Complete series of organizational data over time are not easily available. Developing new metrics and a wider base of data will help to advance the field.

3.6 Causal Relationships and Structure

How are the key concepts causally related to one another? Are there any negative side effects that may be created by variation of the key concepts? What is the underlying structure? How do the causal relationships link together to create feedback loops in the theory? Are there any key concepts that seem to be missing? How can these concepts be grouped together logically?

The underlying structure of theories often can be represented diagrammatically on a single page, allowing the reader to visualize the whole theory. While structure diagrams may not portray all the subtleties of a causal relationship, they allow the reader to see the relationships along several causal links, and they highlight sources of feedback along chains of relationships.
Explicitly identifying how variation in one variable causes variation in others is a primary objective when building a structural diagram. This step is significantly easier when the theory is formalized. The process of formalization forces the theorist to identify the strongest forces. However, this step represents a challenge as organizational theories are often not written in a way that can be interpreted easily using only causal language.

I attempt to select only the variables that seem to have the greatest effect on the behavior. In doing so, I was forced to disregard some concepts in these analyses, which while lending richness to the theory, also add complexity. This complexity, which no doubt is indicative of reality, does not help managers to discern the primary forces at work. The criteria used for omitting concepts from this analysis was to drop the concepts that were not causally explained, and were not identified as having a causal effect on other concepts.

In this step, each causal relationship is traced back to the original work. Notation specifying author, page, and paragraph of the work is made for every causal link (e.g. H&F p 120 ¶ 4). Since the feedback perspective is somewhat novel to organizational theorists, additional links not posited by them were occasionally added to complete feedback loops. However, all my causal assumptions will be clearly noted in the corresponding text by the notation 'KW', and in the causal loop diagrams by dashed arrows.

The causal links are grouped to form feedback loops that are explained individually. All the loops are then combined into one causal loop diagram for that theory.

3.7 Timing

What are the important delays in the causal structure? What is the time horizon for the model? Are there any important delays that have been omitted? Are any of the assumptions likely to change over time?

Issues of delays and timing play an important role in the development of a system dynamics model, but are often overlooked when using alternative analysis methods. Including these timing effects in an analysis has a significant effect on the 'simulated' behavior.
Causal diagram notation for the delays between a cause and an effect are two heavy lines perpendicular to the arrow showing causality.

3.8 Assumptions

What are the underlying assumptions of the analysis? Do the analysts assume perfect information for decision makers? Do they recognize bounded rationality of the decision makers?

Examining the assumptions provides important insight into the modeler's perspective. Although assumptions are often not stated explicitly, they are often important clues to the theorist's mental models, and thus the underlying structure of the theory.

3.9 Behavior and Conclusions

What behavior over time or 'reference mode' is posited by the analyst? Is the structure capable of supporting this behavior? What are the analysts' conclusions? What are the recommended policies? Will they be supported by the proposed structure? Have any unintended side effects of those policies been omitted? Does the augmented structure support the authors' conclusions?

After identifying the posited feedback loops in a structural diagram, the consistency between posited behavior over time and the underlying structure can be examined. Although no comprehensive examination can be done without formal model simulation, the fundamental behavioral characteristics of a simple structure can be verified.

3.10 Reproducibility and Documentation

Is the analysis documented so that the results can be reproduced? Is the documentation available publicly?

In many cases the published work alone does not provide this level of detail. This does not mean that the details are not available, or that the analysis cannot be repeated. However, this paper will only explore the presented theories and analyses, and the published references.
It is interesting to note that full descriptions of models and analyses are convincing to many persons with analytic backgrounds. The presentation of a high level of detail gives the reader confidence as well as insight into the analysis.

3.11 Omissions

What significant effects have been omitted?

After having applied the system dynamics framework, factors which the organizational theorists have ignored may appear to have significance. These factors and their relationships will be noted in this section.

4 STRUCTURAL INERTIA AND ORGANIZATIONAL CHANGE

Michael T. Hannan of Stanford University and John Freeman of University of California Berkeley develop a theory of the population ecology perspective of organizational change. The authors identify structural inertia as the primary force preventing adaptation, and thus giving rise to selection in populations of organizations. The supporting analysis is not in the published work, which made this work the most difficult one to analyze.

4.1 Purpose

Hannan and Freeman establish a theory that differs slightly from other ecological theories, because it builds on several works in the organizational change literature. The authors seem to be trying to integrate several theories into a more extended theory. Their intent seems to move the understanding of these theories forward. Their use of a model is presumably offered to make the theory more concrete, as well as suggest areas for future research. The work was funded by the National Science Foundation.

4.2 Boundary

The concepts within the two circles in boundary diagram below are the ones that Hannan and Freeman include in their analysis. The constructs in the inner circle
are those that are controlled by other concepts in the theory. The exogenous factors are controlled by external conditions.

Figure 1. "Structural Inertia and Organizational Change" boundary diagram

Hannan and Freeman focus most of their analysis at the level of a single organization. However, in this rich analysis, they note effects at the individual, group, and environmental levels as well. While this adds depth to the theory, it creates more complexity than can be synthesized without simulation. They posit that an organization's structural inertia, or an inability to adjust to environmental changes, is the force that creates the ecological behavior on the population level. I focussed on the organizational level analysis.
4.3 Type of Analysis

The structure of Hannan and Freeman's model looks somewhat system dynamics-like because it has a stock and flow structure. They assume four different 'stocks' of organizations in a population: organizations in their original structure, those in reorganization, those that have a new structure, and and those that have died. In this model, organizations move from one state or stock to another, e.g. from original structure to reorganization, over a specified period of time.

![Diagram of stock and flow model](image)

Figure 2. "State Space for the Process of Fundamental Change in Organizational Structure" (The Rj's are instantaneous transition rates.)

In their publication, Hannan and Freeman present their model as shown above. However, they provided no detail about what factors affect the flow of organizations from stock to stock, which made it difficult to examine their methodology. However, they do identify areas for further research about the concepts that affects the rates at the population level. As Hannan and Freeman put it:

"The model ... may be substantively interesting in its own right, assuming that approximate information on dates of leaving states of reorganization can be obtained. It provides a framework for addressing a variety of questions about inertia and change. It has the value of transforming what have been mainly
rhetorical questions about the applicability of the ecological perspective into specific research questions.

While the authors take a large step in understanding the structure of organizational populations, they do not follow through with their analysis at this level. They focus instead on effects at the single organization level. Since this published theory presents much more information on the behavior and relationships at the organizational level, my analysis will be done at that level.

4.4 Key Concepts

The following table outlines concepts used by Hannan and Freeman. These concepts have been included in the causal analysis developed in Section 4.6.
<table>
<thead>
<tr>
<th>Concept</th>
<th>Key Elements</th>
<th>Reference</th>
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| Strategy demanded by environment | • the changing environment in which an organization competes  
• includes changes in market, competitors, customers, technologies, governmental regulations, and economy | H&F p 151 ¶ 2 |
| Appropriateness | • Match between strategy and environment  
• Match between action and environmental outcomes | H&F p 151 ¶ 2 |
| Legitimation | • Endorsement by financial, social, legal systems  
• Conformity to norms of accountability and reliability | H&F p 153 ¶ 2-5 |
| Performance | • Financial performances measures  
• Ability to attract talented members  
• Access to financial resources  
• Organizational reputation | H&F p 151 ¶ 4 |
| Probability of survival | • One less the probability of death over time | H&F p 159 ¶ 3 |
| Amount of buffer resources | • Magnitude of resources that may be applied to developing new routines | H&F p 159 ¶ 5 |
| Reproducibility | • Procedural stability  
• Standardization of routines  
• Institutionalism | H&F p 160 ¶ 1, H&F p 153 ¶ 2,4 |
| Structural Inertia | • Effect of reproducibility  
• Stability  
• Resistance to change | H&F p 163 ¶ 1,2 |
| Investment | • Time spent attempting change  
• Resources devoted to change | H&F p 156 ¶ 6, H&F p 161 ¶ 7 |
| Risk level of strategy | • Organizational change response time  
• Closeness to core competencies | H&F p 156 ¶ 2, 7 |
| Stake in success of members | • Length of service of members  
• Level of members’ organization-specific skills  
• Willingness of members to invest in organization | H&F p 157 ¶ 8 |
| Uncertainty of means / ends connections in strategy | • Tightness of coupling between desired strategy and implemented strategy  
• Uncertainty in strategy forming between actions and environmental outcomes | H&F p 151 ¶ 2 |
Several of the concepts identified above are explained in more detail below. These concepts are referred to repeatedly by the authors. While not all are included in the casual analysis, in keeping with the authors' tone, they are identified here.

**Structural Inertia**

Structural inertia is the property of an organization that keeps it operating in the same manner as it has in the past. Structural inertia arises primarily from internal pressures including politics, sunk costs, and the tendency for precedents to become standards. External factors also contribute, in the form of legal requirements, public legitimation, and trade relations.

Hannan and Freeman define structural inertia in terms of relative time frames. Inertia is the ratio of the total time it takes an organization to detect the need for change and actually make that change to the typical time between environmental shifts requiring change. That is, if an organization can respond quickly to environmental demands, but its environment is changing even more quickly, it has high inertia.

**Accountability**

Organizational accountability arises from the public disclosure of management policies and decisions. Accountability is developed as organizations adhere to the social, financial, political, and legal structures that bind organizations. Accountability makes an organization more attractive to investors.

**Reliability**

Organizational reliability is the ability of an organization to produce products and services with some level of uniformity and consistency over time. In the organizational literature, reliability is considered a result of an organization's competency.

**Performance**

Organizational performance is a multi-dimensional concept that includes factors such as financial performance measures, ability to attract talented members, access to financial resources, and organization reputation. Many factors can
increase an organization's performance, though any single factor alone may not be sufficient.

**Appropriateness**

Appropriateness of strategy and routines of an organization refers to the match between an organizations' existing strategy and routines, and those demanded by the environment. In Hannan and Freeman's population ecology theory, it refers to the characteristics upon which selection is based.

**Reproducibility**

Reproducibility refers to an organization's ability to operate by employing the same structures of communication, authority, and procedures day to day. The term procedural stability might also be used to describe this quality, as it is not likely that the infrastructure of an organization is not really reproduced, or recreated each day.

In this analysis, it is assumed that reproducibility, institutionalism, and standardization of routines, when viewed operationally, can be combined into one concept which we call reproducibility. Hannan and Freeman write:

"In general, organizations attain reproducibility through processes of institutionalism and by creating highly standardized routines." p 154.

Hannan and Freeman make several arguments that the property of reproducibility make an organization resistant to change (p 155). They conclude in Assumption 3 to say "High levels of reproducibility of structure generate strong inertia pressures." I therefore deduce that resistance to change and inertia pressures are equivalent concepts. When used in this sense, inertia refers primarily to the time it takes an organization to detect and respond to an external demand, and not the ratio of that time to the typical time between environmental changes as Hannan and Freeman define earlier.

**Routines**

Hannan and Freeman use the term routines to describe the processes in the organization which are reproduced periodically. The authors adopt this word from a popular theory presented by Nelson and Winter (1982), who believe that
organizations *remember by doing*, and begin to forget when they stop doing. This term is closely related to the idea of reproducibility, which increases as time spent performing a routine increases.

**Selection**

Hannan and Freeman use the term selection in the ecological sense, as in "selection in a population of organizations". Selection implies that the factors affecting the probability of survival and of death are not purely random, but systematically favor organizations with some characteristics rather than others. While this concept specifically relates to populations of organizations, Hannan and Freeman use a related concept 'probability of survival' in their discussion of single organizations.

**4.5 Data, Robustness and Testing**

The authors reference specific validating data for a few of their assumptions, but primarily build on the empirical work of other theorists in the field. While they do show a structure that represents populations of organizations, they provide detail on only a few of the main parameters in this model: death rates of organizations attempting reorganization, and those while not attempting reorganization.

The mathematical relationship between death rates of organizations not attempting change and age of organizations was derived by Freeman et al. (1983) An equation of correlation was developed for this relationship using statistical means.

The authors seem to rely primarily on the empirical verification of other theorists when making these assumptions. Given the authors seem to be integrating several findings into a more comprehensive work, this seems reasonable.

**4.6 Causal Relationships and Structure**

For the analysis of this work, it is necessary to differentiate between causal relationships and other types of relationships, such as coincidence of two concepts. As noted in the work of Péli, Bruggeman, Masuch, and Nualláin (1992), a number of issues arise when trying to interpret Hannan and Freeman's
work in a strictly logical sense. Hannan and Freeman make several formal 'assumptions', as well as many other supporting assumptions. The descriptions of the relationships in these statements are varied. For the purposes of this analysis, the assumptions stating or inferring causality will be explored.

As previously noted, Hannan and Freeman present ideas that pertain to individual organizations as well as ideas that can only be applied to a population of organizations. A single diagram containing concepts on these two levels may lose clarity, and not be considered good form. However, an attempt to stay close to Hannan and Freeman's reasoning will be made. Most of their ideas relate to a single organization, or can be operationalized for that context.

Hannan and Freeman describe a complex web of relationships. The many interlocking relationships were condensed, and by necessity some ideas were omitted. An attempt to capture the theory's primary feedback forces for and against organizational change was made.

Figure 3. Loop 1 of "Structural Inertia and Organizational Change"
Loop #1 - Success reinforces reproducibility which reinforces success.

This self reinforcing loop relates performance to the pressure to change. As an organization experiences increases in performance, pressures to change routines decrease. These organizations have routines which are perceived to be effective, and they continue to practice those routines. As organizations become more efficient due to practice, their reproducibility increases, which eventually causes their performance to increase. As long as organizational performance stays at an acceptable level, the organization will continue to practice existing routines.

Increases in performance increase perceived effectiveness of existing routines, which decrease pressure to change routines. Organizations continue to use routines which they perceive to be effective. On the other hand, decreases in performance increase the pressure to change, which increases attempts to change routines. KW

When attempts to change the routine increase, reproducibility decreases. Any change from an existing routine in which an organization has developed competence over time, to a new routine in which the organization has little or no experience will cause a decrease in competence or reproducibility. H&F p 160 ¶ 1

As reproducibility increases, so does legitimacy. Endorsement by social, legal and financial institutions requires conformity to norms in accountability and reliability. H&F p 153 ¶ 2,4

Increases in legitimacy have a positive effect on performance. As an organization gains endorsement by the financial and social institutions, the organization's ability to attract members, and obtain additional resources increases. Legitimacy is necessary to increase the organization's performance, although it does not ensure success. That is, decreases in legitimacy will decrease an organization's performance. H&F p 154 ¶ 1
Loop #2 - Aging increases legitimacy which reinforces aging.

This reinforcing loop describes a natural increase in legitimacy and commitment to an organization over time. As long as an organization is successful, legitimacy increases, which allows its performance to increase. This loop only functions in the positive sense as age does not decrease. Age however stops increasing when the organization dies.

As the age of organization increases, the average length of service of its members increases. Assuming no major changes have taken place during the organizations' existence, this is probably true. H&F p 157 ¶ 8 As the length of service of members increases, so does their stake in the success of the organization. For long time members, the costs of switching to a new organization are high. Hannan and Freeman describe this phenomena at the member level. H&F p 157 ¶ 8

As the stake in success of members increases, the willingness of members to invest in the organization increases. Members become more willing to invest in the organization to increase its probability of survival. H&F p 157 ¶ 8
As members' willingness to invest increases, so does the performance, with a time delay. Because organizations rely upon their members to perform the routines reliably, an increase in members' willingness will increase performance. H&F p 157 ¶ 7

As the performance increases, so does the probability of survival. Although these concepts cannot be equated, if an organization has consistently increasing performance, it will continue to attract talented members and obtain additional resources which will increase its probability of survival. KW

As the probability of survival increases, the longer the organization will continue to age. This relationship makes more sense if the probability of survival (or death) is for the next several time periods. If the probability of survival became low enough, the organization would die, and cease to age. KW

---

**Figure 5. Loop 3 of "Structural Inertia and Organizational Change"**

**Loop #3 - Inappropriateness motivates change, which increases uncertainty.**

This reinforcing loop becomes a strong factor when performance is decreased. This causes 'pressures to change routines' to increase which leads to increasing 'attempts to change'. The authors posit that there is decoupling between the desired strategy and the implemented strategy, and that there is uncertainty associated with the desired strategy. Both of these factors serve to decrease the match, or appropriateness between the strategy demanded by the environment
and the strategy that is actually implemented. This mismatch causes a decrease in the performance, which again increases the pressure to change routines.

This loop is instrumental in the switch from increasing performance to decreasing performance. As the appropriateness drops due to an external factor - a change in strategy demanded by the environment - it causes the performance to drop. This causes the reinforcing loops which were working for the organization to work against the organization. For instance, the increase in pressure to change and increase in attempts to change also decreases the reproducibility of an organization's routines. This decrease in reproducibility will be reflected in a further decrease in performance.

As the appropriateness decreases, so does organizational performance. Appropriateness is the match between the strategy demanded by the organization's environment and the implemented strategy. A highly appropriate strategy will be one whose characteristics cause performance to increase. Although this is not stated explicitly, it is inferred from the discussion of selection models based on the randomness of this match. KW

As the pressure to change increases, attempts to change increase. In order to relieve the pressure from members, investors, and business partners, organizations will attempt to change their strategy to improve their performance. This relationship is also consistent with the notion that disconfirming evidence is needed to motivate significant change. KW

As the organization increases attempts to change, the uncertainty between means and eventual ends increases. As controlling managers in organizations gain experience in their existing routines, they develop a sense of means and ends connections. If strategy or routine is in a state of change or is brand new, there is less certainty about the effects of their actions. Previous 'rules of thumb' used to manage may be inappropriate. (Sterman 1994) KW

As the uncertainty between means and ends increases, the appropriateness of organizational routines decreases. Higher uncertainty about the effects of actions results in more errors in judgment. Management errors decrease appropriateness of their routines. H&F p 151 ¶ 2
As changes are attempted, the controllability of an organization decreases. When changes are initiated, individual members become more uncertain and more aware of their self-interests, causing struggles in internal politics and balance of power to increase. KW As the diversity of members' interests increases, the extent to which organizations can be controlled decreases. H&F p 151 ¶ 4 "The process of dismantling structure and building another make organizational action unstable."

A decrease in controllability causes a decrease in appropriateness of organizational routines. That is, in addition to managers having a perfect understanding of the situation, they must also be able to redirect the organization as they see fit. Hannan and Freeman write "... if March and others are right, organizational change is largely uncontrolled" and "Then organizations staffed by highly rational planners may behave essentially randomly with respect to adaptation." H&F p 151 ¶ 3 Cohen, March, and Olsen developed these ideas in their "garbage can theory". (1972)

Figure 6. Loop 4 of "Structural Inertia and Organizational Change"
Loop #4 - Change causes shifting of resources away from existing routines.

This reinforcing loop is similar to Loop #1 working against the successful organizational change. It demonstrates another mechanism whereby decreases in performance lead to an eventual decrease in reproducibility.

An increase in pressure to change over time will lead to an increase in riskiness of strategy. Increases in riskiness increase the time for an organization to change, and therefore increase structural inertia. As the duration of change increases, so do the resources devoted to that change. As resources are shifted away from the existing routines, reproducibility is decreased.

Decreases in reproducibility decrease legitimacy in the social, financial and legal institutions. Low legitimacy decreases the probability of survival and performance. H&F p 153 ¶ 9

Decreases in performance increase attempts to change. This relationship is shorthand for decreases in performance increase pressure to change which, when sustained, cause increases in attempts to change. Although not stated specifically, Hannan and Freeman note that "there are large lags in response to environmental change to attempts by decision makers to implement change". Since performance is the only channel through which changes in the environment are identified in this theory, I deduce that decreases in performance cause increases in attempts to change. KW

An increase in attempts to change causes increase in risk level of strategy.
"Organizations facing bad times will follow riskier and riskier strategies ... " H&F p 161 ¶ 1

Higher risk strategy infers change that is closer to the core of the organization. "The view of organizations as having a core which is more difficult to modify than its more peripheral structures is not new." H&F 156 ¶ 2 "Thus we expect the likelihood of [successful] change by transformation to decline as one proceeds up the hierarchy [of organizational levels]." H&F 156 ¶ 7 In this relationship, the likelihood of successful change is inversely proportional to the risk.

The closer the desired change is to the core of the organization, the more time is required to make the change. Hannan and Freeman describe layers of
organizational competencies. "The layers supposedly differ in characteristic speeds of response." H&F p 156 ¶ 6

As the amount of time spent changing increases, so does the amount of resources spent on change. H&F p 161 ¶ 7

As the finite resources are shifted from existing routines to developing new routines, the amount of buffer resource decreases. If buffer resources are not sufficient for change efforts, resources may be shifted away from existing routines. When any resources are shifted away from existing routines, the capacity to perform those routines decreases. H&F p 160 ¶ 7

As capacity to perform existing routines decreases, so does the reproducibility. If the capacity to perform existing routines diminishes, the competence to perform those routines may be degraded from lack of use. This results in a decrease in reproducibility. H&F p 160 ¶ 7

Figure 7. Loop 5 of "Structural Inertia and Organizational Change"
Loop #5 - Resources necessary for change are used up in process of change.

This loop explains the effect of buffer resources on the probability of successful change. Essentially, a large amount of buffer resources allows an organization to spend time and money without detracting from the performance of existing routines, and increase the probability of successful change. A sufficiently large buffer can mitigate the effects of Loops #4 and #5.

Increases in resources devoted to change decrease the amount of buffer resources. This is a simple accounting relationship. It is interesting to note that organizations with very large buffer resources - often very large organizations - may not be impacted by the cost of change. Small organizations, however, are threatened by even small costs of change because they lack the reserves to buffer them. H&F p 159 ¶ 3

A large amount of buffer resources will increase the probability of successful change. "Successes in reorganization may depend on the magnitude of resources applied to the task." H&F p 159 ¶ 5
Figure 8. Hannan and Freeman's "Structural Inertia and Organizational Change"
4.7 Timing

The time horizon for the causal diagram analysis is essentially the lifetime of an organization. The population ecology approach may be more effectively observed over the lifetimes of multiple organizations. Concepts of interest would include death rates, rates of reorganization, successful reorganization rates, rates of founding organizations, etc. However, most of the authors' explanation of cause and effect is related to the forces and their effects at a single organizational level. As Hannan and Freeman mention, building a population level model requires more data was available in the field.

Much of the authors' discussion incorporates references to time and delays. The reinforcing 'age and legitimacy' loop assumes a linear increase in legitimation and thus performance. The idea of structural inertia is defined by a ratio of delays: the typical delay of changes in environmental demands, and the delay of an organizational change.

In this causal diagram, there are small delays in many of the loops. There is a significant delay between a decrease in performance and an increase in attempts to change. There is a delay between an increase in reproducibility within the organization and the increase in external legitimacy. There is also a delay between an increase in attempts to change and an increase in risk level of strategy. Increased riskiness occurs only as continued attempts are made with no observable increases in performance. Also, as resources are shifted from existing routines to the change process, or new routines, there is a delay in the reduction of competency or capacity to perform that comes from disuse.

The relative size of these delays is not evident, but the overall effect of a delay in a single positive feedback loop is to slow down the exponential increase, or exponential decrease of the parameters.

4.8 Assumptions

Hannan and Freeman make many of their assumptions explicit. All of these assumptions are embedded in, or supported by the causal loop structure.
Assumption 1. Selection in populations of organizations in modern societies favors forms with high reliability of performance, and high levels of accountability.

Assumption 2. Reliability and accountability require that organizational structures be highly reproducible.

Assumption 3. High levels of reproducibility of structure generate strong inertial pressures.

Assumption 4. Reproducibility of structure increases monotonically with age.

Assumption 5. The level of structural inertia increases with size for each class of organization.

Assumption 6. The process of attempting reorganization lowers reliability of performance.

Assumption 7. Organizational death rates decrease with size.

Assumption 8. Structural reorganization produces a liability of newness.

Assumption 9. The death rate of organizations attempting structural change rises with the duration of the reorganization.

Assumption 10. Complexity increases the risk of death due to reorganization.

4.9 Behavior and Conclusions

Hannan and Freeman do not state explicitly the posited behavior of an organization’s performance over time. They do, however, state that “individual organizations are subject to strong inertial forces, that is, they seldom succeed in making radical changes in strategy and structure in the face of environmental threats.” The typical behavior I infer from this statement is a large shift in the strategy demanded by the environment, that causes a downward trend in performance until the organization finally dies.

This behavior is clearly supported by the causal loop structure. The two reference modes that are supported by the multiple positive loops in the causal
loop structure are an exponential increase in performance, or an exponential
decrease in performance.

The key to this theory seems to be the level of uncertainty associated with
developing a new strategy, as well as the controllability of the organization. In
this system, Loop #3 plays a pivotal role in sealing the fate of an organization
that attempts change.

Hannan and Freeman state many of their conclusions clearly in the form of
theorems. They are outlined below, along with discussion of whether the
proposed behavior can be supported by the causal loop structure derived from
the authors' discussion.

Selection favors high inertia.

Theorem 1. Selection within populations of organizations in modern societies
favors organizations whose structures have high inertia.

To interpret this theorem, we assume structural inertia is caused by high
reproducibility, and represents the time for an organization to change which is
proportional to the resistance to reorganization. This interpretation does not
incorporate the rate at which the environment is changing as in Hannan and
Freeman's formal definition, but is the focus of Hannan and Freeman's assertion.
Using their formal definition "high" inertia would involve specifying both the
time it takes an organization to change and the average time for an organization's
environment to change. The authors only refer to the time it takes the
organization to change.

The structural diagram supports this theorem if we assume that the strategy
demanded by the environment does not change. That is, as reproducibility
increases, both performance and structural inertia increase. Increased
performance increases the probability of survival, which on the population level
increases probability of selection.

Structural inertia increases with age.

Theorem 2. Structural inertia increases monotonically with age.
We assume the behavior posited by this theorem is simple correlation of increases in age with increases in structural inertia. Again, the working definition of structural inertia is used, assuming the rate of change in environmental demands on an organization is constant.

Increasing structural inertia as the age of an organization increases can be supported by the causal loop analysis. As an organization increases its reproducibility, (and therefore its structural inertia), it also increases its performance, and the probability that it will survive and grow older. The relationship between age and inertia cannot be easily characterized without a more detailed model of the authors' theory, however.

It is interesting to note the theory's underlying structure can also support extremely different behavior. If an organization's reproducibility decreases due to attempts to change, then performance will decrease. As the performance decreases, the rate of attempted changes increases. Increases in attempts to change continue to decrease the reproducibility, and therefore decrease structural inertia.

Consistent with this scenario, other forces may be affecting the level of structural inertia. As Hannan and Freeman note, decreases in performance increase the rate of attempts to change, which in turn increase the riskiness of the attempts. Hannan and Freeman note that structural inertia is dependent on the riskiness, or closeness of the prescribed change to the core of the organization. So this loop can have the effect of increasing structural inertia. As noted before, the actual behavior of structural inertia over time will depend on the relative strengths of these loops, and therefore on the particular circumstance of an organization.

**Probability of survival increases with age.**

**Theorem 3.** Organizational death rates decrease with age.

The behavior described by this theory is directly supported by Loop 2 in our causal structure. As an organization grows older, its members become more committed, investors become more willing to invest, and routines become more stable. This increase in legitimation increases performance which increases the probability of survival, assuming no environmental change.
As the probability of survival for each particular organization increases over time, then so does the survival rate of the population of organizations. That is, the population of organizations is made up of many organizations which have a increasing chance of survival over time, (rather than some having an increasing chance of survival and some having a decreasing chance).

It is important to note that this behavior is described by the predominant effect of Loop 2. This loop naturally reinforces an organization's good performance over time. This pattern can be nullified by forces decreasing legitimation and performance through the other loops, however.

**Attempts to change decrease probability of survival.**

Theorem 4. Attempts at reorganization increase death rates.

This theorem is also supported by the causal loop diagram. As the organization increases the attempts to change, reproducibility is decreased. A lower level of reproducibility will decrease legitimacy, which will decrease performance. Decreases in performance will decrease the probability of survival. Another decrease in performance will cause this loop to continue its downward pressure on reproducibility and performance, and thus probability of survival.

**Complexity decreases probability of survival during attempts to change.**

Theorem 5. Complexity increases the risk of death due to reorganization.

This theorem is indirectly supported by the causal structure. Hannan and Freeman state, referring to organizational complexity, "*Long chains of adjustments may reduce the speed with which organizations can reorganize in response to environmental threats and opportunities.*" This increase in time to change will increase the amount of resources necessary for change, and decrease the reproducibility of existing routines. Once again, decreased reproducibility decreases performance, which decreases probability of survival.

### 4.10 Reproducibility and Documentation

The analysis in the authors' work would not be able to be reproduced from the information provided in the written document alone. The paper provides several
of the equations used in the analysis, but does not fully specify the analysis. No data is explicitly provided, although it may be available from the referenced sources.

4.11 Omissions

In this analysis, several relationships have not been explicitly identified by Hannan and Freeman. While some of these assumptions may have been implied by the authors, I show them here to highlight any assumptions made in this analysis. The following hypothesized relationships have been added to Hannan and Freeman's analysis to complete several feedback effects.

Increased legitimacy is necessary for increased performance.

Increases in attempts to change increase uncertainty in means and ends connections.

Decreases in performance increase pressure to change, and eventually increase attempts to change existing routines.

As the risk level of a strategy increases, the closer the recommended change will be to the organization's core.

As the probability of survival increases, the age of an organization increases.
5 A MODEL OF ADAPTIVE ORGANIZATIONAL SEARCH

Daniel Levinthal and James G. March wrote this paper for the Journal of Economic Behavior and Organization 2 in 1981. The authors present a model of rational adaptive search of an organization for new technologies in an uncertain environment. The authors assume that organizations learn from experience and adapt to the perceived changes. The authors contend that ambiguity in the environment combined with rational adaptation creates the variation in the organizational performance.

5.1 Purpose

March and Levinthal build on their past work on rational adaptation to include elements of uncertainty. The authors' research was funded by grants from the Spencer Foundation, the National Institutes of Education, the Hoover Institution, and the Stanford Graduate School of Business.

5.2 Boundary

The concepts within the two circles in the boundary diagram below are the ones that Levinthal and March include in their analysis. The constructs in the inner circle are those that are controlled by other concepts in the theory. The exogenous factors are controlled by external conditions.
Levinthal and March also focus their analysis at the organizational and environmental levels. Unlike the other two theories, these authors include characteristics of the environment including the nature of returns to and opportunities for innovative and refinement discoveries.

5.3 Type of Analysis

Levinthal and March create a formal dynamic model using a Basic program. They develop a time series of performance, and behavior data. Parameters are recalculated every discrete time interval. Levinthal and March make use of a variety of mathematical and logical functions to define relationships between variables, including several stochastic functions. The time series aspect of this
analysis lends itself very well to implementation using system dynamics modeling.

5.4 Key Concepts

The following table identifies the key concepts used in Levinthal and March's work.
<table>
<thead>
<tr>
<th>Concept</th>
<th>Key Elements</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Search</td>
<td>• Investment in the identification or discovering of new technologies</td>
<td>L&amp;M p 193 ¶ 2</td>
</tr>
<tr>
<td>Refinement discovery</td>
<td>• Identification of incremental modifications to existing technology base</td>
<td>L&amp;M p 192 ¶ 2</td>
</tr>
<tr>
<td></td>
<td>• Value of refinements are distributed normally;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>those with the highest estimated value are implemented</td>
<td></td>
</tr>
<tr>
<td>Innovation discovery</td>
<td>• Identification of revolutionary shifts in technology</td>
<td>L&amp;M p 192 ¶ 4</td>
</tr>
<tr>
<td></td>
<td>• Value of innovations are distributed normally;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>those with the highest estimated value are implemented</td>
<td></td>
</tr>
<tr>
<td>Adaptation</td>
<td>• Change in investment strategy due to perceived result of previous strategy</td>
<td>L&amp;M p 189 ¶ 2</td>
</tr>
<tr>
<td></td>
<td>• Increase in search efficiencies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Adjustment of performance goals</td>
<td></td>
</tr>
<tr>
<td>Propensity to search</td>
<td>• Organization's perception and attitude toward the benefits of technological</td>
<td>L&amp;M p 195 ¶ 2</td>
</tr>
<tr>
<td>Performance goal</td>
<td>search</td>
<td></td>
</tr>
<tr>
<td>Actual performance</td>
<td>• Depends on state of its technology, the costs of search, and randomly</td>
<td>L&amp;M p 191 ¶ 3</td>
</tr>
<tr>
<td></td>
<td>varying environment</td>
<td></td>
</tr>
<tr>
<td>Performance shortfall</td>
<td>• Magnitude of difference between actual performance and targeted performance,</td>
<td>L&amp;M p 189 ¶ 3</td>
</tr>
<tr>
<td></td>
<td>when performance goal exceeds actual performance</td>
<td></td>
</tr>
<tr>
<td>Slack</td>
<td>• Difference between actual performance and target when actual exceeds target</td>
<td>L&amp;M p 189 ¶ 4</td>
</tr>
<tr>
<td>Investment in refinement</td>
<td>• Amount of search targeting greater efficiency, and discoveries in the</td>
<td>L&amp;M p 189 ¶ 3</td>
</tr>
<tr>
<td>search</td>
<td>near neighborhood of present activities</td>
<td></td>
</tr>
<tr>
<td>Investment in innovative</td>
<td>• Resources and energy devoted to 'irresponsible' search</td>
<td>L&amp;M p 190 ¶ 1,2</td>
</tr>
<tr>
<td>search</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undiscovered refinements</td>
<td>• Pool of potential improvements that could be made to existing technology</td>
<td>L&amp;M p 190 ¶ 3</td>
</tr>
<tr>
<td>Change in environmental</td>
<td>• Randomly varying environmental variable which directly affects an</td>
<td>L&amp;M p 191 ¶ 3</td>
</tr>
<tr>
<td>behavior</td>
<td>performance</td>
<td></td>
</tr>
</tbody>
</table>
Search

The amount of search is the amount of resources devoted to identifying or discovering new technologies. Search technologies are described as "any semi-stable specification of the way in which an organization deals with its environment, functions and prospers." The authors define two types of search: refinement and innovative.

Refinements

Refinements are incremental improvements in an existing technology base. They are created by investing in refinement search. Refinement discoveries do not necessarily represent improvements to an organization's existing methodology.

Innovations

Levinthal and March use the term innovation to mean a revolutionary shift in technology. These are significant changes in processes or products which replenish the pool of available refinement discoveries, and decrease the efficiency of performing refinement search.

Adaptation

The authors identify three types of organizational learning or adaptation. The first is the adaptation of search strategies. This refers to the change in search investment strategy, i.e. the ratio of investment in refinement vs. innovative search. The authors note "Behavior that is associated with success tends to be repeated; behavior that is associated with failure tends not to be repeated." The second type of adaptation is that of search competencies. As organizations gain experience performing one type of search, they become more efficient at doing that type of search. This concept is similar to Nelson and Winter's (1982) "learn by doing" idea. The third type of adaptation that Levinthal and March include is the adaptation of aspirations. The tendency for organizations to adjust their goals to their historical performance has been observed by others. (McPherson 1961, Senge 1990)
Learning from experience

Firms learn to repeat actions that seem to be correlated with increases in performance. Organizations also learn not to make investments with actions that seem to be causing decreases in performance. The authors note that lessons learned can be erroneous, due to the uncertainty about the usefulness of refinements and innovations. March and Levinthal also note that the speed at which organizations 'learn' affects their overall performance. (Interestingly, the authors contend that very fast learners do not perform as well as slower ones.)

Slack

Slack refers to a situation when an organization's actual performance exceeds its targeted performance. The authors note that this situation typically causes management to invest in innovative search.

Propensity to search

The propensity to search represents the management's attitude toward the benefits of search, either for refinements or for innovations. The overall propensity to search affects the propensity for refinement and innovative search. These propensities are affected by the learning from past experiences, i.e., if search in the past has been successful and, and increased performance, the propensity to search will increase.

Number of draws

The number of draws is the number of refinement or innovative discoveries that are made by an organization over a period of time. The two factors affecting this number are the amount of investment in search and the efficiency of search. Levinthal and March refer to these discoveries as 'draws' because of the uncertainty of the value of the discoveries. Often discovered refinements or innovations do not represent improvements to the organization's existing technologies. March and Levinthal also include an error in judging the value of the discoveries. This causes organizations' to decide to adopt refinements or innovations that do not ultimately increase the organization's performance.
Efficiency

The authors note efficiencies of refinement search and innovative search are gained through experience. Given fixed investment in either type of search, the efficiency increases at a decreasing rate. Contrary to the Nelson and Winter's "learn by doing" theory, efficiency (or competency) in either refinement or innovative search is not decreased by disuse. Efficiency in refinement search is decreased by each new innovation.

5.5 Data, Robustness and Testing

The authors performed many different runs of the model for each set of parameters. The testing of the model included variations of the following parameters:

- the time horizon of the organization
- the rate of goal adaptation
- the rate of propensity adaptation
- the level of uncertainty in the environment
- trends in the state of technology

It seems the authors tested these parameters to their logical extremes, although some parameters represent subjective concepts which have no standard units of measurement. The graphical results of the sensitivity tests do provide interesting insight into the behavior of the model.

Although the authors performed several runs for a large number of scenarios, there are some puzzling assumptions made in the model itself. For instance, the authors note "...partial decoupling of the investment budget and the allocation of resources to specific projects." The complex relationship between these two variables seems to be almost completely decoupled, and seems to cause the organization to invest more total resources to search than they have available.

The authors do not identify specific sources of their data. The method by which many of the parameters have been set or initialized is not referenced to empirical studies. They note that the assumptions embedded in their model stem from observations from behavioral studies of decision-making, but do not specify which studies.
5.6 Causal Relationships and Structure

![Diagram showing causal relationships between performance shortfall, actual performance, investment in refinement search, refinement discovery, and their interconnections.]

Figure 10. Loop 1 for "A Model of Adaptive Search"

Loop #1: Performance shortfalls and refinement investment

This balancing loop works to eliminate performance shortfall. As the performance of an organization decreases, the shortfall increases. This spurs an increase in investment in refinement discoveries. These discoveries then cause the performance to increase, and the shortfall to decrease.

Performance shortfall is defined by the difference between the organization's performance goal, and the actual performance of the organization. An increase in this shortfall causes management to increase the investment made in refinement search. L&M p 189 ¶ 3

As refinement search increases the number of refinement discoveries increases. Although an increase in refinement search investment is not adequate to ensure an increase in discoveries, it is necessary for an increase. L&M p 189 ¶ 3

An increase in the number of refinement discoveries increases organizational performance. Although there is error in estimating the value of the discoveries, on average, the refinements that get implemented result in an increase in organizational performance. L&M p 189 ¶ 3
Figure 11. Loop 2 for "A Model of Adaptive Search"

**Loop #2: Refinement search and efficiency of refinement search**

This balancing loop has includes many of the same relationships as Loop #1. It increases the efficiency of the investment in refinements. As investment in refinement increases, the efficiency of refinement search increases. This increases the refinement discovery rate, which increases performance and decreases performance shortfall.

As investment in refinement increases, the experience doing refinement search increases, and thus, the efficiency of refinement search increases. The authors assume that, given a fixed investment in refinement, refinement efficiency increases, but at decreasing rate over time. This relationship describes the classic learning curve effect. L&M p 193 ¶ 3

An increase in efficiency in refinement search increases the discovery rate for refinements, all else being equal. That is, given a certain non-zero pool of undiscovered refinements, an increase in refinement investment will increase the number of refinement discoveries. L&M p 193 ¶ 2

Again, an increase in refinement discovery rate, on average, increases the actual performance of the organization. L&M p 189 ¶ 3
As performance increases the shortfall is reduced. A decrease in shortfall will decrease the amount of investment in refinement, which decreases the investment in refinement search. L&M p 189 ¶ 3

Finally, a decrease in investment in refinement will slow down the increase in efficiency. While the efficiency does not decrease due to disuse, the rate of increase is slowed even more by a decrease in the amount of investment in refinement. L&M p 193 ¶ 2

![Diagram of refinement discovery and undiscovered refinements]

Figure 12. Loop 3 for "A Model of Adaptive Search"

**Loop #3: Undiscovered refinements and refinement discoveries**

This balancing loop represents the use of a fixed pool of resources -- the discovery of potential refinements. As the number of refinement discoveries increases, the number of undiscovered refinements for a given state of technology decreases. Alternatively, as the number of undiscovered refinements increases, the number of discoveries of those refinements increases, all else equal. L&M p 190 ¶ 3

The authors assume a fixed pool of potential refinements for a given state of technology. This pool of undiscovered refinements is refilled by each new innovation. This is reminiscent of Kuhn's theory of scientific evolution. (Kuhn 1970, Sterman 1985)
Figure 13. Loop 4 for "A Model of Adaptive Search"

**Loop #4: Slack resources and innovative search**

This reinforcing loop takes effect when the organization perceives that it has slack resources. Slack brings about increases in innovation, which leads to increases in refinements, and in performance, which lead back to increases in slack.

As perceived slack increases, the investment in innovative search increases. The authors ...

"assume that the primary source of resources for innovation ... is organizational slack. That is, the model reflects a tendency for organizations to support search for innovation from 'excess' resources and to contract such search when resources are apparently short, and for successful firms to make more radical product and process innovations than unsuccessful firms." L&M p 194 ¶ 4

An increase in investment in innovative search increases the innovative discoveries. Increases in investment increase the number of draws from the pool of innovative discoveries which increases the number of innovative discoveries. (It is interesting to note the authors assume there is no inherent limit to the pool of undiscovered innovations in the model.) L&M p 193 ¶ 2
Innovative discoveries replenish the pool of undiscovered refinements. Innovations provide a whole new set of problems that can be solved to make the technology more efficient and marketable. L&M p 190 ¶ 3

As undiscovered refinements increase, so does the rate of refinement discovery. This relationship assumes a non-zero investment in refinement. L&M p 193 ¶ 2

When the number of refinement discoveries increases, the value of those that are implemented increases. This increase in value improves the actual performance of the organization. L&M p 189 ¶ 3

As performance increases further, the perception of slack also increases. Since slack is defined by the difference between the organization's actual performance and the targeted performance, an increase in performance will increase the slack, all else being equal. L&M p 190 ¶ 1

![Diagram](attachment:image.png)

Figure 14. Loop 5 for "A Model of Adaptive Search"
Loop #5: Investment in innovative search and the efficiency of innovative investments

Loop #5 is a reinforcing loop which strengthens the effect of Loop #4 - Slack resources and innovative search. As the investment in innovative search increases, the efficiency of doing innovative search increases. An increase in search efficiency has the effect of increasing the rate of innovative discoveries, which replenishes the pool of undiscovered refinements more often. Increases in refinements increase the organization's performance, and thus increase slack.

Increases in innovative investment increase the organizational experience in performing search for innovations, which increases the efficiency of performing innovative search. L&M p 193 ¶ 3

Increases in innovative search increase innovation discoveries. Levinthal and March refer to the innovation discoveries as the number of draws. L&M p 193 ¶ 2

Again, as the rate of refinement discoveries increases, the value of refinements that are implemented increases. This increase in value improves the actual performance of the organization. L&M p 189 ¶ 3

As actual performance increases, the perception of slack also increases, all else being equal. L&M p 190 ¶ 1

An increase in slack increases the resources available for innovative search, and the propensity to search. This causes an increase in the investment in innovative search. L&M p 194 ¶ 4.
Loop #6: Performance goal adjustment decreases perception of slack.

This negative or balancing loop works against the reinforcing Loop #4 -- Slack resources and innovative search. As the organization's performance increases, after a delay, the organization's targeted performance also increases. This has the effect of decreasing the perceived slack, and decreasing the investment in innovation. Eventually, the decrease in innovation will have the effect of decreasing performance.

Any adjustment in performance will cause, after a delay, a like adjustment in the organization's performance goal. The tendency for organizations to adjust their expectations to their actual performance has been widely noted. L&M p 190 ¶ 3

An increase in the performance goal decreases the perceived slack in resources. L&M p 189 ¶ 4

A decrease in perceived slack will decrease the amount of investment in innovative search. L&M p 194 ¶ 4.
This decrease in innovation investment will decrease innovative discoveries, which will eventually lead to a decrease in refinement discoveries and thus performance. L&M p 190 ¶ 3, p 193 ¶ 2, p 189 ¶ 3

Figure 16. Loop 7 for "A Model of Adaptive Search"

**Loop #7: Performance goal adjustment decreases perception of shortfall.**

This positive or reinforcing loop weakens the effect of the balancing Loop #1 - Performance shortfalls and refinement investment. Loop 1 has the effect of shortening the time spent investing in refinements in order to decrease the performance shortfall. In Loop 7 the shortfall is instead decreased by an adjustment of the performance goal. Essentially, decreases in performance decrease the performance goal, which decreases performance shortfall, which decreases refinements, and eventually decreases performance.

When the actual performance of an organization decreases, it causes the performance goal to decrease also, after a delay. L&M p 190 ¶ 3

A decrease in the performance goal makes the performance shortfall decrease. L&M p 189 ¶ 3

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As the performance shortfall decreases, the perceived need to invest and therefore the investment in refinement search decreases. L&M p 189 ¶ 3

As the investment in refinements decreases, so does the number of refinement discoveries. L&M p 189 ¶ 3.

A decrease in the number of refinement discoveries decreases the firm's actual performance even further. L&M p 189 ¶ 3

![Figure 17. Loops 8 and 9 for "A Model of Adaptive Search"

**Loops #8 and #9 - Adjustments to search propensities**

These reinforcing loops (which are not shown in the main diagram) perform an important function. When the perceived payoff from investments becomes negative, the propensity to invest in refinement search is adjusted downward and the propensity to invest in innovative search increases. In general, when the organization experiences a decrease in performance, it switches to the opposite investment strategy.

As the actual performance of the organization increases, it increases the propensity to invest in the type of search that it most recently increased. In other words, positive changes in performance makes an organizations do more of the
same. Negative changes in performance motivate the organization to change investment strategies. L&M p 195 ¶ 1

Given the authors assumptions, increases in performance come primarily through the discovery of refinements. As the performance increases, the propensity to invest and thus the amount of investment in refinements continue to increase. L&M p 189 ¶ 3

Increases in investment will result in increases in refinement discoveries, which cause increases in performance on average. This reinforcing loop continues to be dominant until the pool of undiscovered refinements is depleted (Loop #3). L&M p 189 ¶ 3

Decreases in performance, caused by the drop in return to investments in refinement, decrease the propensity to invest in refinement, and increase the propensity to invest in innovation. L&M p 195 ¶ 1

As the propensity and the investment in innovation increases, so do the discoveries in innovations. L&M p 193 ¶ 2

Because innovative discoveries do not provide immediate value to the company, increases in innovative discoveries do not increase performance. L&M 190 ¶ 1

As performance continues to drop, the propensity to invest in innovation decreases, and the propensity to refine increases. That is, the investment strategy is again reversed. L&M p 195 ¶ 1

As investment in refinements increases, the refinement discoveries also increase. This is possible because the recent investment in innovation has replenished the undiscovered refinements. L&M p 189 ¶ 3

Refinement discoveries increase the organization's performance. L&M p 189 ¶ 3

These search propensity adjustment loops cause the organization to switch back and forth between investing in innovation and refinement. Changes in investment strategy are initiated in periods of decreasing performance. Improvements in performance can only be achieved by performing refinements with an adequate pool of undiscovered refinements. The occasional emphasis on innovations is necessary to replenish the undiscovered refinements.
5.7 Timing

The authors note the dependence of results on the relative delays and time horizons of the modeled organizations. Many of their conclusions are about the effects of the following delays: the time to adjust performance goals, the time to adjust search propensities, and the time horizon of organizations.

Some delays seem to have been omitted from the analysis. The delay between investment and discovery has not been explicitly identified in the analysis. Delay between an increase in refinements and the performance returns to those refinements is not included.

5.8 Assumptions

The authors make a number of assumptions as outlined below.

Success of an organization depends on technology improvements, which require investment in technological search.

Number of draws from a given technology is a function of the size of search expenditure, search efficiency, and the number of potential discoveries.

Organizations tend to invest in refinement search when they perceive performance shortfalls, and innovation search when they perceive slack.

Only refinements provide direct value to the organization's performance. Innovative activities "cannot be justified in terms of their expected return for the organization."

5.9 Behavior and Conclusions

There is a tendency for organizations to improve their performance over time.

The general structure of the model supports this assumption, given the underlying assumptions and structure. The corresponding reference mode for this conclusion is an upward trend in performance over time. The rather complex structure can produce this behavior in a number of ways.
If the system starts with a pool of undiscovered refinements and high goals, the performance will be improved by the balancing loop of investment in refinement and performance (Loop #1). As the undiscovered refinements dwindle (Loop #3), the refinement search propensity adjustment loop takes over (Loop #7), and shifts the investment strategy to innovate (Loop #4). After no improvement in performance, the search propensity is readjusted (Loop #8) to emphasize refinement search (Loop #1). The performance is again improved by continued investment in refinements until this stock of undiscovered refinements in depleted.

This conclusion is supported by the structure as described by the authors. The authors note "it is possible that improvement in performance is due more to properties of the search environment than to the learning process." However, without the search propensity adjustment process, an organization would continue to automatically invest in refinements (Loop #1) even when the pool of undiscovered refinements was completely depleted, given the policy to invest in refinements when there is a performance shortfall. This would result in decreasing performance.

**Performance tends to be lower for organizations that adjust their propensity to search very quickly.**

The construction of their model in Basic supports this conclusion. Managers, while rational, do not take into account the environmental uncertainty that affects their performance. The fast learning organizations tend to lock onto 'false signals' in the system when adjusting to the high performance strategy, or away from a low performance strategy. These organizations learn the erroneous lesson that increases in search propensity decrease performance.

As environmental uncertainty increases, the actual performance exhibit variability. In fast learning organizations, short term decreases in performance are misinterpreted, and cause changes in investment strategy. Organizations which do not adjust their investment propensities as quickly, do not adapt to high short term variation in performance. They do not react as quickly to 'noise' in the environment.
It is interesting to note that the conclusion is supported with two assumptions. The environmental changes are 'noisy' and do not necessarily represent valid market demand shifts. The second assumption is the average frequency of change in the environment is much lower than the organizational response frequency.

High levels of investment in search optimizes performance for organizations with a longer time horizon. No investment optimizes performance for those with shorter time horizons.

Although reasonable, this conclusion is not easily supported from the causal loop structure. The more investment in innovation, the higher the average value of those discovered over time. This tends to support the first of these conclusions. However, given the structure as the authors have described it, if there is no investment in refinement search, there will be little improvement in performance, in the short or long term.

Changes in resource allocation are less responsive to learning than to organizational success and failure.

This conclusion can be explained using the model structure. This conclusion simply notes that Loop #1 and #4 are the dominant forces in determining behavior. That is, when organizations perceive success, they are more likely to invest in innovation. When they have a performance shortfall, they invest in refinement. The search propensity adjustment loops (#7 and #8) are weaker according to this conclusion. This says more about the authors' parameterization than the structure of the model itself.

One difficulty with this conclusion is this: if the refinement and performance loop (#1) were always stronger than the refinement propensity adjustment loop (#7), after the pool of undiscovered refinements was zero, the organization could not increase its performance. So although this conclusion can be supported by the structure, it is not consistent with the authors' other conclusions about behavior.
High environmental uncertainty reduces the frequency of slack periods when technology is improving or declining slightly.

While this conclusion can be supported by the structure, it is more likely a result of specific parameterization of the authors' model. When the value of the technology is declining, a high level of noise in the environment can actually increase the performance. However, when a technology's value is increasing, high levels of uncertainty or 'noise' in the environment tend to decrease performance. Essentially, the addition of noise makes the performance tends to the mean.

Major innovations usually affect the position of the organization permanently.

This conclusion can be supported by the structure. The authors assert that innovative discoveries have varying degrees of long term value, and that this variation is stochastic. In the system, an innovation has value (increases performance) only indirectly through the refinements that succeed it. Given the structure that authors have described, this means that a major innovation would increase the number of undiscovered refinements significantly higher than other innovations.

This large number of undiscovered refinements allows the organization to invest in refinement successfully for a longer period of time (Loop #1). An important driver of this behavior is the adjustment of the performance goal. Because the authors assume that refinements are usually motivated by performance shortfalls, as performance increases, the performance goals must also be increasing to create the perceived shortfall. This would have the effect of continued increases in the organizations' performance, and the creation of resources for further investment. Although the organization may not perceive that it has slack because it has increased its performance goals, continued increases in performance will create actual slack for the organization.

Subjective success tends to lead to subjective success and a subjective failure tends to lead to subjective failure.

The authors note the tendency for organizations to have several contiguous performance shortfall periods, as well as several contiguous slack periods.
Several periods of shortfall is definitely supported by the structure, especially when the goal is continually being adjusted upward as the performance increases, to maintain the appearance of a slack condition. The authors note that the performance adjustment rate effects this conclusion.

Contiguous periods of slack can be explained structurally but may conflict with other conclusions. Once a slack condition is perceived, the investment in innovation will be increased. New innovative discoveries will increase the undiscovered refinements. This loop (#4) requires a non-zero value of refinement innovation to function. As refinement discoveries increase, the performance also increases, thus sustaining the slack condition. In this scenario, the goal adjustment loop (#6) will have less of an effect. So although the performance increases will cause an adjustment of the performance goal upward, the effect of the innovative discoveries on the performance is greater.

Several contiguous periods of slack can be explained by the structure, but seem to assume a particular parameterization of the model. Specifically, investment in refinement must continue to be effective even when the organization invests most of its resources in innovative search. Also, the organization must eventually decrease this investment in refinement so that the apparent return to innovation seems to decrease, and the investment emphasis can be shifted back to refinement. The ability for investment in innovations to increase performance seems somewhat contrary to the original assumptions of the authors.

In the published work, the authors present data supporting this conclusion that does not separate the analysis of transitions from successes to failures and transitions from failure to success. It would be interesting to analyze these two separately to note whether the behavior favors one state or the other.

5.10 Reproducibility and Documentation

March and Levinthal present their entire documented Basic program in the publication. They also explain the various experimental runs that were performed. Although the program was not verified by reentering and testing it, there is seems to be enough information provided in the publication to do so.
One disadvantage for the authors of making the model available for inspection is that the reader has more visibility into the details, and is thus able to critique the model more easily. Inconsistencies between the explanation and the modeling can be readily identified. I found a few inconsistencies with the parameter definition. For example, in equations 16, 17, and 18 on page 195, the Q variables are professed to be either one or zero. In the program however, these variables seem to be initialized at 40.

5.11 Omissions

Although there are many forces that March and Levinthal have omitted, the most conspicuous ones are the effects of competition in the market, and interactions among organizations. I think these forces could have a significant impact on the posited behavior.
6 The dynamics of revolutionary organizational change, Exploring the punctuated equilibrium theory with computer simulation

M. Anjali Sastry explores Michael Tushman and Elaine Romanelli's theory of punctuated equilibrium, in which organizations experience change in bursts between longer periods of stable operation. The theory is explained "organizations change through brief, revolutionary punctuations of longer, convergent, equilibrium phases."

The author builds a system dynamics model of Tushman and Romanelli's change theory "Organizational Evolution: A Metamorphosis Model of Convergence and Reorientation." This model provides useful insight into the validity of their theory, as well as some omissions.

6.1 Purpose

Sastry's publication has a dual purpose. Sastry developed a system dynamics model to provide insights into the punctuated equilibrium theory. The author notes that during development of the model important questions about the theory are generated. Assumptions that are made in the theory become explicit, and therefore more easily discussed. At this phase of theory exploration, the model is intended to show general patterns of behavior over time, and to identify important areas for data collection during the next stage of exploration.

6.2 Boundary

Due to the author's approach, the boundary of this model is easily identified. The diagram shown below identifies the endogenous, exogenous, and omitted concepts. Tushman and Romanelli, and therefore Sastry focus their work on the organizational level.
6.3 Type of Analysis

Sastry employs system dynamics modelling which allows detailed mapping of complex relationships. This type of modelling lends itself well to the analysis of dynamic historical behavior. Similar to the analyses in this paper, the structure of the model is determined by the assumptions outlined in the original theory. When the relationships between concepts have not been fleshed out by the original theorists, Sastry makes explicit assumptions.

The graphical representation of the model is presented showing the interrelationships between variables. The formulation listing is also readily available from the author, though not included in the published work.
6.4 Key Concepts

Sastry presents clearly what the key 'constructs' are in her model. These are briefly presented in the following table.
Table 3. A. Sastry’s "The dynamics of revolutionary organizational change"

<table>
<thead>
<tr>
<th>Concept</th>
<th>Key Elements</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic Orientation</td>
<td>• Core values, beliefs, products, technologies, power relationships, control systems, and organizational structure</td>
<td>AS p 7</td>
</tr>
</tbody>
</table>
| Inertia                      | • Extent to which commitments by internal participants are solidified into institutional norms  
                                 |             |             |
|                              | • Strength of relationships with buyers, suppliers, and financial backers     |             | AS p 7      |
| Appropriateness              | • Closeness of match between its strategy and that demanded by the environment | AS p 7      |
| Competence                   | • Ability to execute its strategic orientation                              | AS p 7      |
| Performance                  | • Defined by the lessor of an organization's appropriateness or competence   | AS p 7      |
| Pressure for change          | • Result of sustained low performance due to lack of consistency among activities or environmental changes that render a strategic orientation no longer effective | AS p 7      |
| Ability to change            | • Capacity to reassess environmental opportunities and constraints  
                                 |             | AS p 11 ¶ 2 |
| Perceived performance        | • Exponentially delayed performance due to lags in reporting                 | AS p 41     |
| Desired performance          | • Standard by which an organization measures its performance                | AS p 9 ¶ 2  |
| Required strategic orientation| • Preferred products, markets, technologies, organizational structure given exogenous determinants such as competition or regulations or endogenous ones such as life stage | AS p 10 ¶ 2 |
| Change in strategic orientation| • Shifting of an organization's markets, products, structure, power relationships | AS p 7, AS p 11 ¶ 4 |
| Performance gap              | • Difference between desired performance and perceived performance           | AS p 9 ¶ 2  |
Strategic orientation

The strategic orientation of an organization is a multi-faceted concept which includes its "core values, beliefs, products, technologies, power relationships, control systems, and organizational structure." Strategic orientation defines the means by which it will reach its goal, its business, and how it competes.

Inertia

Inertia is the resistance to all but incremental change. Sastry notes two different dimensions to this concept: structural and social. Structural inertia is the "extent to which commitments by internal participants are solidified into institutionalized norms." Social inertia is the "strength of relationships with buyers, suppliers and financial backers." Unlike Hannan and Freeman, Sastry models these two types of inertia separately.

Appropriateness

The appropriateness of the firm's strategic orientation is the closeness of match between its strategy and that demanded by the environment. In addition to 'organization-environment fit', measures of appropriateness also include the consistency of activities within the organization.

Competence

A firm's competence is its "ability to execute its strategic orientation." This concept is similar to an organization's reproducibility of executing its routines as noted in Hannan and Freeman.

Performance

An organization's performance is defined by the lessor of the organization's appropriateness or competence. That is, if the organization adopts a highly appropriate strategy but is not competent at executing that strategy, its performance decreases. Likewise, if an organization is highly competent at performing an inappropriate strategy, its performance will suffer.
Pressure for change

Pressure for change is the 'result of sustained low performance due to lack of consistency among activities ... or changes the render a strategic orientation no longer effective'. This pressure is from the board of directors, the customers, or the executives, and is motivated by low performance.

6.5 Data, Robustness and Testing

Sastry's model does not use historical data of firms to test her model, but attempts to recreate the behavior as conjectured by Tushman and Romanelli. Although many of the concepts included in the model are 'soft variables', and typically not measured in organizations, empirical evidence would help to validate this and other models of organizational change.

Although the author does not use field data to verify the model, the model does create punctuated equilibrium behavior described by Tushman and Romanelli. In order to create the behavior described by Tushman and Romanelli, Sastry identifies several additional assumptions that must be made in addition to the ones that they originally identified. Parameters in the models are tested to their extremes, and the behavior is 'plausible'.

6.6 Causal Relationships and Structure

Sastry provides the reader with a simplified causal loop diagram. The punctuated equilibrium theory can be summarized in two loops. However, a close inspection of her model shows more feedback loops.
Loop #1: Performance and pressure to change

Loop #1 in Figure 20 is a goal-seeking loop. It works to close the gap between desired and perceived performance. As performance decreases, pressure to change increases which causes the organization to change its strategic orientation. Changes in strategic orientation increase the appropriateness of the strategic orientation, which in turn increase performance.

In more detail, as the performance of an organization decreases, the perceived performance also decreases, after a delay. AS p 41

As the perceived performance decreases, relative to a fixed desired performance level, the performance gap or shortfall increases. AS p 9 ¶ 2

As the performance shortfall increases, the pressure to change also increases. AS p 8 ¶ 2

As the pressure the change continues to increase, eventually the organization will respond with a change in strategic orientation. AS p 8 ¶ 2

The change in strategic orientation increases the one-dimensional variable for strategic orientation. AS p 9 ¶ 1
As the strategic orientation changes, the difference between it and the strategic orientation required by the environment decreases. As the difference decreases, the appropriateness of the strategy increases. AS p 9 ¶ 1

As the appropriateness of the strategy increases, the performance of the organization is increased, all else being equal. AS p 9 ¶ 1

Figure 21. Loop 2 for "The dynamics of revolutionary organizational change"

Loop #2: Change, inertia, and competence

This is a reinforcing loop which has the effect of decreasing the performance of a firm that has changed its strategic orientation. Similar to Loop #1, as performance decreases, the pressure for change increases, and eventually the change in strategic orientation increases. As the change takes place, the inertia of an organization decreases, and the competence decreases. As competence decreases, so does the organization's performance.

As performance decreases, the gap between the perceived performance and the desired performance increases. AS p 41

As the performance gap increases, the pressure for change increases. Eventually, an increase in pressure to change will result in a change in strategic orientation. AS p 8 ¶ 2
An increase in change in strategic reorientation decreases the firm's inertia. AS p 11 ¶ 3

A decrease in inertia results in a decrease in competence. AS p 9 ¶ 4

Decreases in competence cause decrease in the firm's performance. This further increases the gap between desired and perceived performance. AS p 9 ¶ 4

Figure 22. Loop 3 for "The dynamics of revolutionary organizational change"

**Loop #3: Inertia and ability to change**

This reinforcing loop tends to decrease the ability for an organization to change when it does not experience change for some time. It can also make change easier for an organization that attempts change often. As change in strategic orientation decreases, inertia increases over time. As inertia increases, the ability to change decreases, which decreases the change in strategic orientation.

As the rate of change in strategic orientation decreases, inertia increases. The longer the organization has to develop structural and cultural norms, the more inertia around those norms will be created. AS p 11 ¶ 3

As inertia increases, the ability to change decreases. Although the organization becomes very efficient at performing the existing routines, they become less flexible and less able to modify those routines. AS p 11 ¶ 2
As the ability to change decreases, the rate of change decreases. As the firm becomes less able to change, it attempts changes less often. AS p 11 ¶ 3

Figure 23. Loop 4 for "The dynamics of revolutionary organizational change"

**Loop #4: Pressure for change and change**

This balancing loop works to alleviate the pressure to change. As pressure to change increases, eventually change in strategic orientation is attempted. During this time, the pressure for change is decreased temporarily. This loop prevents the organization from continuously initiating change during a low performance period. After change is attempted, the pressure to change is temporarily relieved while the organization waits for the results of that change. AS p 12 ¶ 1
Figure 24. A. Sastry's "The dynamics of revolutionary organizational change"
6.7 Timing

Sastry addresses the role of time delays explicitly. She notes several delays that are necessary to create the punctuated equilibrium behavior. For instance, there are delays of perception and reporting between the actual performance change and the perceived performance change. Similarly, there is a delay between an increase in pressure to change and the resulting change in strategic orientation. This delay consists of the time to make the decision to change and in what direction, as well as the time to implement the change.

The author notes that these delays are critical to determine the observed punctuated equilibrium behavior. Without them, the same model creates behavior resembling incremental change.

In the model, the time horizon is not explicitly identified. The simulation runs for 160 time periods. The author notes that these periods could be months, quarters, or years. At this phase of exploration, the model is intended to show general patterns of behavior over time, and to identify important areas for data collection during the next stage of exploration.

6.8 Assumptions

Organizations are able to identify the right strategic orientation.

This assumption is made by the author to enable the model to produce the behavior conjectured by Tushman and Romanelli. The model structure assumes that when the pressure to change increases to a threshold, the organization changes its strategic orientation to be more appropriate. There is no uncertainty about the optimum strategy to be implemented.

Pressure to change is only borne out of poor performance.

In the version of the model presented, the only motivator for change is low performance. The author suggests a modification to the existing model that would support proactive motivation for change. Presently, pressure for change is generated from outside forces such as investors, executives, or customers. An additional mechanism is needed to reflect the tendency for organizations to
increase their own pressure to change before performance shortfall reaches a critical level.

There is no adjustment of performance goals.

In the model, the performance goal is fixed and does not adjust upward or downward with performance. The author does not included this widely observed phenomenon. If this effect were added, the role of inertia would become even greater, as any long term decreases in performance would be relieved by a downward adjustment in the desired performance.

Strategic orientation is a one-dimensional variable.

This assumption is clearly a simplification of reality which makes the model easier to comprehend and explain. The author notes "this assumption ... provides us with more optimistic results than would the more realistic case in which multiple dimensions are incorporated." Sastry contends that the original theory while mentioning the dimensions of strategic orientation does not give any indication of how the orientation should be formulated. The author notes this as an area for further work.

Organizations know when change in strategic orientation would be counter-productive.

Managers do not to react to pressure to change caused by low performance after they have just made a change in strategic reorientation. The model assumes "the organization can both discern when a reorientation would be counter-productive and can refrain from attempting to change its strategic orientation cases where poor performance is caused by low competence."

The required strategic orientation has no noise.

There is no noise in the required strategic orientation. That is the required strategy exhibits no random element of variation. As the author notes, although a stochastic component could be added easily to the required orientation, it is not done in this exercise.
6.9 Behavior and Conclusions

The posited behavior for this theory depends on the nature of the required strategic orientation. If this variable exhibits a one time change. The performance of the organization drops quickly, then exponentially adjusts back to its original level.

If the strategic orientation is a moving target, the behavior is that of 'punctuated equilibrium'. That is, when the strategic orientation is continuously changing at a steady rate, the organization's performance fluctuates. As the performance decreases due to an increasingly inappropriate strategic orientation, the organization eventually reorients its strategic orientation, and thus increases its performance. As the required strategy continues to change, the cycle is repeated.

The author identifies several new assumptions that are necessary for Tushman and Romanelli's punctuated equilibrium thesis to be accurate. These ideas are not addressed in depth in the original work.

There is a substantial lag in the firm's response to its environment.

This behavior is created by the structure of the model. Due primarily to the delays identified in the timing section above, the organizations do not respond immediately to pressures for change. As noted in Loop #1, when an decrease in the performance happens, it takes time for the organization to realize it due to reporting and perception delays. Additionally, it takes time for an organization to select and implement the change in strategic orientation.

Organizations must know when change in strategic orientation would be counter-productive.

This observation is important to keep the organization from initiating one strategic reorientation after another. Once a reorientation has been initiated, Loop #2 causes a decrease in competence, performance, and ultimately an increase in pressure to change. If the model has no mechanism (Loop #4) to relieve this pressure, new changes would be initiated.
6.10 Reproducibility and Documentation

The author presents the graphical ithink representation and a simplified causal loop diagram of the model. Although the detailed equation listing is not included, the author offers the reader a complete model listing and simulation results upon request.

6.11 Omissions

While numerous effects have been omitted from the analysis, a few are particularly interesting and probably relevant to the understanding of organizational change. These include competitive market forces, both deterministic and stochastic, as well as resource accounting and the associated limits.
7 DISCUSSION ABOUT THE DYNAMICS OF ORGANIZATIONAL CHANGE

In this section, I compare the three theories explored in sections 4, 5, and 6. The table below presents a comparison of the theories as they relate to the applied framework. Table 5. presents a cross-reference of key concepts used in the theories. Sections 7.1 through 7.11 highlight differences and similarities discovered during the process of analysis. Finally, I reflect on the process in Section 7.12.

Table 4. System dynamics framework and organizational change theories

<table>
<thead>
<tr>
<th></th>
<th>Hannan and Freeman</th>
<th>March and Levinthal</th>
<th>Tushman and Romanelli</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose</strong></td>
<td>• Integrative work to support the population ecology work</td>
<td>• Expand upon their rational prior adaptation work</td>
<td>• Expand upon their prior punctuated equilibrium work</td>
</tr>
</tbody>
</table>
| **Boundary**           | • Organizational level analysis  
                          • Uncertainty between ends and means  
                          • Reproducibility | • Organizational level analysis  
                          • Search routines and policies | • Organizational level analysis  
                          • Performance  
                          • Social and structural inertia |
| **Type of analysis**   | • No formal analysis presented | • Basic program | • System dynamics model |
| **Key Concepts**       | • Structural inertia  
                          • Organizational uncertainty  
                          • Performance | • Innovative and refinement search  
                          • Innovative and refinement discovery  
                          • Performance | • Desired and perceived performance  
                          • Appropriateness of strategy  
                          • Strategic orientation |
| **Data / Robustness / Testing** | • None - formal analysis not presented | • Model is tested with stochastic environmental response | • Model is tested with varying environmental changes |
| **Casual Relationships and Structure** | • Five reinforcing feedback loops | • Complex system of nine reinforcing and balancing loops. | • Four reinforcing and balancing feedback loops |
| Timing | • Response time to environmental changes | • Time to adjust search propensities  
  • Time horizon of organization  
  • Time to adjust planning goals | • Delays between pressure to change and change in strategic orientation  
  • Delays between actual and perceived performance |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavior / Conclusions</td>
<td>• Structural inertia makes it difficult for organizations to change in response to environmental changes</td>
<td>• Organization effectively respond to changes in their environment by performing search for improvements in technologies.</td>
</tr>
</tbody>
</table>
| Omissions | • Market dynamics  
  • Financial resource limitations | • Market dynamics | • Market dynamics  
  • Financial resources |

Key concepts of the three theories are cross-referenced in the following table. Although there are many similarities in the concepts, the way in which they are related and defined varies significantly.
Table 5. Key concepts for three theories of organizational change

<table>
<thead>
<tr>
<th>Hannan and Freeman Structural Inertia</th>
<th>March and Levinthal Adaptive Search</th>
<th>Tushman and Romanelli Punctuated Equilibrium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legitimation</td>
<td>-</td>
<td>Strategic Orientation</td>
</tr>
<tr>
<td>Structural inertia</td>
<td>-</td>
<td>Inertia</td>
</tr>
<tr>
<td>Strategy demanded by environment</td>
<td>Change in environmental behavior</td>
<td>Required strategic orientation</td>
</tr>
<tr>
<td>Appropriateness of strategy</td>
<td>-</td>
<td>Appropriateness</td>
</tr>
<tr>
<td>Reproducibility</td>
<td>Efficiency in refinement and innovative search</td>
<td>Competence</td>
</tr>
<tr>
<td>Performance</td>
<td>Actual performance</td>
<td>Performance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Perceived performance</td>
</tr>
<tr>
<td>Pressure to change routines</td>
<td>Performance shortfall</td>
<td>Pressure for change</td>
</tr>
<tr>
<td>Time between environmental changes</td>
<td>Timeframe for typical environmental change</td>
<td>-</td>
</tr>
<tr>
<td>Time for organization to change</td>
<td>Time for organization to change</td>
<td>Change in strategic orientation</td>
</tr>
<tr>
<td></td>
<td>Performance goal</td>
<td>Desired performance</td>
</tr>
<tr>
<td>Pressure to change routine</td>
<td>Performance shortfall</td>
<td>Performance gap</td>
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<td></td>
<td></td>
<td>Pressure for change</td>
</tr>
<tr>
<td>Investment</td>
<td>Investment in innovative / refinement search</td>
<td>-</td>
</tr>
<tr>
<td>Pressure to change routines</td>
<td>Propensity to search</td>
<td>-</td>
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<tr>
<td></td>
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<td>Refinements</td>
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<td></td>
<td>Innovations</td>
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<tr>
<td></td>
<td>Adaptation</td>
<td>-</td>
</tr>
<tr>
<td>Amount of buffer resources</td>
<td>Slack</td>
<td>-</td>
</tr>
<tr>
<td>Stake in success of members</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Probability of survival</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Risk level of strategy</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Uncertainty in means / ends connections</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Undiscovered refinements</td>
<td>-</td>
</tr>
<tr>
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<td>-</td>
<td>Ability to change</td>
</tr>
</tbody>
</table>
7.1 Types of change

The three theories portray organizational change slightly differently. Levinthal and March consider change to be largely adaptive. They identify three main areas of change or adaptation: the switch between search propensities for innovation and refinement search strategies, changes in performance goals, and increasing efficiencies of search.

Hannan and Freeman consider the change in an organization away from existing routines. Although this type of change would seem to follow a change in strategic direction, Hannan and Freeman focus on the operational effects of organizational change.

Tushman and Romanelli, as interpreted by Sastry consider the strategic change away from the existing strategic orientation. They focus on the strategy, and seem to assume that the organization will implement corresponding routines with relative ease.

7.2 Performance goal

Each of three theories incorporate a performance goal, either explicitly or implicitly. There is some variation in how performance is conceptualized, but all three include financial performance. (Venkatraman and Ramanujam 1986) Decreases in actual performance relative to the goals tended to be the primary driver for organizational change in each of these theories.

In March and Levinthal's adaptation theory, they assume that a shortfall in performance usually causes an increase in search for refinement. They also assume that the organization has two primary sets of routines that it can perform: one that its typically performed under successful conditions and one when they have declining performance. Specifically, when the organization's performance decreases, the firm responds by engaging in refinements. When performance increases, the organization searches for innovations. If the performance is not improved by the standard response, the organization switches its search strategy. March and Levinthal maintain that switching between these two strategies is how organizations deal with decreases in performance relative to their performance goal.
Hannan and Freeman's analysis explicitly states that decreases in performance motivates changes to the existing set of routines. Although they do not explicitly identify a performance goal, it is inferred.

7.3 Goal Adjustment

Another force that is omitted by Hannan and Freeman, and Sastry, but included by March and Levinthal is the tendency for organizations to adjust their goals to their performance. While all three theories include either explicitly or implicitly the concepts of actual (or perceived) performance and desired performance, only March and Levinthal consider aspiration adjustment to be worthy of inclusion. Because all three theories include the concept of performance goal as the primary motivator for organizational change, any adjustment to the goal is relevant to the analysis of organizational change.

In March and Levinthal's model, this force has the effect of muting the response to any longer term performance trend. While the other two theorists do not include this relationship between actual performance and desired performance, they do include the concept of inertia.

In Sastry's punctuated equilibrium model, inertia has the effect of decreasing the ability to change, which ultimately has the effect of slowing the response to required changes. Hannan and Freeman do not explicitly identify the relationship between inertia (reproducibility) and a dampened response to performance decreases.

The difference in posited behavior between increased inertia and adjusting goals is not dramatic. Differentiating whether a given response to a decrease in performance is simply postponed, or is dampened due to goal erosion will be difficult without empirical data (e.g. budgeted vs. actual performance data).

7.4 How difficult is change?

Each of the theories posits different ideas about the level of difficulty associated with organizational change. Hannan and Freeman posit that structural inertia and high levels of uncertainty between means and ends make it difficult to change successfully.
Hannan and Freeman assume that it is very difficult (if not impossible) to maintain multiple sets of routines without practicing them regularly. They contend that if the organization did not perform innovative search for some time, the skills required to perform innovative search would degrade. Therefore, in Hannan and Freeman's opinion, it would be much more difficult to switch between the two different search routines than it seems in March and Levinthal's adaptation theory.

Levinthal and March recognize virtually no difficulty in initiating change in strategy. Changes in propensity to conduct innovative or refinement search are simply a matter of rational adaptation, or learning. The authors make no mention of difficulty in making these changes. Tushman and Romanelli also acknowledge the resistance to change but believe an adequate level of pressure will eventually overcome the inertia.

When adaptation or change is thought to be difficult, several forces are identified as being possible causes. Hannan and Freeman ascribe to the 'learn by doing' theory. That is organizations can only maintain competence in routines that they practice regularly. Back-up (change) routines become atrophied with disuse. Hannan and Freeman also note that uncertainty makes change difficult.

7.5 Organizational uncertainty

Hannan and Freeman are the only ones to identify organizational uncertainty as a force affecting change. Uncertainty plays a important role in their proposed behavior. They posit two types of uncertainty: uncertainty in connections between means and ends, and uncertainty related to the linkage between desired routines (strategy) and implemented routines.

Although not mentioned specifically in any of the theories, the presence of delays in the underlying structures contribute to the uncertainty between means and ends.

In March and Levinthal's theory, they note that longer delays in making decisions to change search strategies result in greater success. (This delay keeps the organization from reacting to false signals in the environment.) One reason for this delay could be uncertainty. It is interesting to note that if we consider
uncertainty in a different theoretical framework, it could actually improve performance.

7.6 Initiating change

Acknowledgement of delay between initiating a change and seeing the results is explicitly acknowledged in Sastry’s punctuated equilibrium work. That is the fact that pressure to change is released immediately after a change has been initiated, before the results of the change are observed in the performance.

Hannan and Freeman do not identify this period of abeyance in their theory. March and Levinthal include this waiting period implicitly. In their theory, the time delay for a change in strategy defines the waiting period. That is, after a change has been initiated (refinement search begun), if the performance shortfall is not resolved after the period of delay, the organization changes search strategies to innovation.

7.7 Environmental uncertainty

All of the theories recognize some random element in the environment as it affects organizations’ performance, although each considers its effect slightly differently. Hannan and Freeman consider how changes in the strategy demanded by the environment affect the appropriateness of the existing strategy, which in turn affects performance.

Levinthal and March consider one type of uncertainty to be located in the market, and directly affecting the organization’s performance. They also include other stochastic influences of technology in the search and discovery of innovations.

Sastry identifies environmental uncertainty as an important element to test Tushman and Romanelli’s theory, but prefers to add it to the analysis after the behavior of the endogenous system has been understood. This uncertainty manifests itself in the perceived required strategic orientation. So this uncertainty could be the management uncertainty as Hannan and Freeman posit, or it could be attributed to random noise in the market itself, as Levinthal and March propose.
7.8 Resource accounting

Two of the theories include resource considerations, but in one case only as a beneficial effect. Hannan and Freeman note that the amount of buffer resources increases the probability of successful change. That is, as the amount of buffer resources increases, the more an organization can spend to accomplish change without getting to a critical situation. They do not include the resource limitations that are typically experienced as performance decreases.

March and Levinthal included accounting for the costs of search or change, but did not model hard limits for investment in search. They include the costs of search in their performance calculation, as well as value of technologies discovered. When allocating resources however, they seem to allocate more than they have. They do not identify the underlying assumption.

Tushman and Romanelli do not include resource accounting at all, but relate actual performance only to the level of appropriateness of strategic orientation. Sastry identifies this as a necessary area for inclusion in a more fully developed model.

There are a few reasons why the resources might be relevant in a model of organizational change. It seems that an organization that has experienced low performance for multiple periods may experience situations where the resources are not adequate for the necessary change efforts, and is therefore doomed.

7.9 Competence

All three theories incorporated the growth of competence over time for an organization performing a given set of routines. Hannan and Freeman note that periods without changes to routines increase the reproducibility (reliability, competence). Similarly, changes to routines decrease the organization's competence to some floor level as the experience with previous routines is lost.

Levinthal and March incorporate increasing search efficiencies as the organization performs each type of search. As the organizations gain more experience, they become more efficient. They note that the efficiency of refinement search is decreased whenever a new innovation is discovered.
Levinthal and March do not include decreases in efficiency of innovation due to disuse.

It is interesting to note that Levinthal and March assume some level of competency to do the different types of search. For example, although the organization may not perform innovative search for a lengthy period of time, when it is employed the rate of innovative discovery is unaffected. This structure assumes basic competence and ability to adopt new technologies, to actively change their products and methods.

Interestingly, in the simulation, the search propensities which drive the amount of investment in the two types of search are always non-zero. That is, there is always some investment in both types of search. This parameterization would be more likely to cause the generally successful performance results that March and Levinthal cite.

7.10 Behavior in the absence of environmental change

If we assume that the external forces that demand a different organizational strategy or routine are absent, the behavior of the three structures varies somewhat.

In Hannan and Freeman's structure, the default behavior is continued increases in performance due to continually increasing competence, legitimization, and reproducibility. The structure developed by Hannan and Freeman will create exponential increases in performance in the absence of environmental perturbation.

Sastry's punctuated equilibrium model also creates an ever increasing trend in performance. Without any change in the required strategic orientation, an organizations' strategies are highly appropriate and competencies for these strategies increase. Increasing competence increases performance.

Levinthal and March propose a different behavior. Their adaptive theory structure assumes that even without random external shifts in required strategy, the nature of learning infers change in the technologies used. Because they assume any given technology has finite potential, an organization's performance increases until the potential has been exploited. Then the organization's
performance decreases. This dynamic of fluctuating performance would be evident even without unexpected environmental variation.

Although these behaviors seem to contrast greatly, March and Levinthal have chosen to establish the boundaries of the model to include characteristics of the environment, whereas, Hannan, Freeman, and Sastry choose to focus their analyses on the structure of the organization itself. They omit modelling of the structure of the (technological) environment. The chosen boundaries of the models have a significant impact on the behavior of the model. While it is not clear whether Hannan, Freeman, and Sastry would agree or disagree with March and Levinthal's characterization of the technological environment, it is clear that they have chosen to omit it from their analysis.

The absence of market interaction and competition from all three theories should be highlighted here. These forces, if included in the model would hinder the general pattern of increasing performance over time. Although these forces could conceivably be lumped with random environmental changes, many effects of the market are not random. Inclusion of non-random market forces in future research will make these theories more realistic.

7.11 Size of organizations

Two of the three theories examined noted that the size of an organization has an effect on the organization's strategy or ability to change. March and Levinthal do not consider any of these factors in their theory. Hannan and Freeman's population ecology theory includes the effect of 'buffer' resources which, they note, are typically greater in larger organizations. Buffer resources increase the probability of successful change for larger organizations.

In Sastry's punctuated equilibrium model, she notes the size of an organization may cause the required strategic orientation to change. In this model, the size of an organization increases with the social and structural inertia and this affects the desired strategic orientation. Although not identical to Hannan and Freeman's structure, it does have similarities if we note that the age, size, and inertia of an organization are correlated.
7.12 Reflections

There were many interesting challenges in applying this framework to these three different methodologies. The rich, rather unstructured analysis, of Hannan and Freeman presented the greatest challenge for analysis. There was an abundance of detail presented in this work, on several different levels of organizational analysis. Determining the strongest forces and effects was significantly more subjective than for the other two theories. After deciding to focus only on the organizational level, I wondered if I hadn't disregarded important forces. The concepts in Hannan and Freeman's work were usually not discussed from a causal standpoint. The authors rarely identified causal relationships explicitly.

In a few cases there were significant differences between the concepts used by the theorists and operationalized concepts used by system dynamicists. For example, in Hannan and Freeman's theory, the age of an organization is not a concept that lends itself to causal analysis. It is preferable to use a parameter that can either increase or decrease such as 'length of time since last reorganization'. Because Hannan and Freeman believe that organizational change is very difficult - so difficult that organizations rarely succeed in attempts at change, it is not appropriate to replace the concept 'age of an organization' with the 'length of time since last reorganization'.

Until I did this analysis, it was not clear to me exactly how or why these theories differed. The conclusions of these theories seem to place them along a common spectrum (change is easy, change is not easy - but possible, and change is nearly impossible). After exploring the structure of the theories, it became clear that the choice of boundary, structure, and scope had more to do with the differences in posited behavior. Although the theories did have some common concepts, there were often very important forces arising out of concepts that were specific to a theory.

I found interesting that March and Levinthal's approach simulated the change technologies without changing the organization's process of routines. They presented a simplified model, with out many of the implied details. For instance, when a major technological innovation is discovered, does an organization retrain the experts in previous technology to be experts in the new technology, or
does the organization look for new members? If there is significant turnover in membership, does the organization at some point become a new organization? Nonetheless, the idea that an organization's routines can be change routines themselves seems to be reminiscent of the organizational learning literature, and are intriguing.

Interestingly, Hannan and Freeman were alone in fully addressing what seems to be the very real concept of uncertainty. March and Levinthal imply some uncertainty as the organization must search for improvements in technology, but conceptualize the uncertainties as having well characterized distributions. Given the dynamic complexity of the economic, political, social, and competitive environments, I think uncertainty should be included in any complete model of organizational change. However, in Hannan and Freeman's model, there are no mitigating forces for the uncertainty in their model. They describe a structure that has no balancing loops, and therefore cannot represent the entire picture.

Clearly, each of the three models is a simplifications of reality (by definition). It would be interesting to combine the forces posited in all three of these models to create a more comprehensive structure. This structure would require formal modelling for us to understand how the dynamic forces posited in these theories would interact. Formalized modelling, however, requires data.

In general, I think the lack of data in this field makes it extremely difficult to determine which forces are the strongest. In this field, there is not even consensus on the general pattern of performance behavior over time. Gathering data on actual and budgeted performance, over time for many organizations would seem to be an important next step. In addition, data on the amount of investment in new technologies, methods, or markets in these organizations would help to ground these theories in real world observation.
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