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# Self-Organization in Career Systems: A View from Complexity Science

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Hugh P. Gunz . Benjamin M. Bergmann Lichtenstein . Rebecca G. Long

University of Toronto  
eMail: hugh.gunz@utoronto.ca  
University of Hartford  
eMail: benjamin@mail.hartford.edu  
Mississippi State University  
eMail: rlong@cobilan.msstate.edu

This paper seeks to understand the dynamics of career systems by exploring how the study of other complex systems can shed light on the complex careers that are becoming increasingly the norm. We begin by defining career systems as a set of work roles and the influx of people occupying those roles, within an organization or in “boundaryless” industries. Then, we explain numerous patterns in career systems—described as “self-organization”—through rigorous metaphors drawn from studies of “self-organized criticality” (Bak, 1995) and adaptation in interconnected networks (Kauffman, 1993). Implications for strategic human resource management and careers research are identified.

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## INTRODUCTION

Until the end of the 1980s it is probably fair to say that the primary goal of most careers researchers was to uncover the laws governing individual careers as orderly systems of progression within (e.g., Mahoney and Milkovich, 1973; Stewman and Konda, 1983; Rosenbaum, 1984; Pfeffer, 1985; Stewman, 1986; Forbes, 1987; Sonnenfeld and Peiperl, 1988; Gunz, 1989a) or between organizations (e.g., White, 1970; Payne and Payne, 1983; Yamaguchi, 1983; Hout, 1984; Sobel, Hout and Duncan, 1985; Hachen, 1992). More recently, the emphasis in the literature has increasingly been placed on interorganizational, so-called “boundaryless” careers (Arthur and Rousseau, 1996). That is, careers are being conceptualized by some theorists as more fluid arrangements based on networks of people who come together to work on specific project ventures. The orderliness of career movement within well-defined organizational boundaries disappears in this perspective.

Although in this paper we share a concern for *patterns of career mobility*, we change the unit of analysis and move to the organizational and supra-organizational level of career systems (a term we define below; cf. Lawrence, 1990). Specifically, we are interested in the patterns of career movement that are evident within any group of work roles whose boundary may or may not be coterminous with an organization. Although there is evidence that career systems are influenced by and

influence the strategic choices implemented by organizational decision makers (Gunz and Jalland, 1996a), little is known of the dynamic behaviour of these career systems—for example, how quickly they respond to changes, how stable they are over time—even when they are bounded by a single organization, much less when they span organizations in the complex patterns now being described.

In this paper we take a small step toward understanding the dynamics of career systems at these multiple levels, by exploring how these complex systems can be understood by exploring the study of other complex systems. According to research in the complexity sciences, a surprising range of complex systems seem to organize themselves so as to avoid two extremes: too much order, and too little order (Kauffman, 1993; Brown and Eisenhardt, 1997). Studies of spontaneous order emerging from seemingly random events (Kauffman, 1993; Bak, 1996) suggest that many systems evolve to a stable state at the “edge of chaos,” allowing them to adapt to change without losing their integrity. Here, we explore the possibility that career systems may exhibit similar behaviour.

In this paper we first define our unit of analysis, the career system. Next, we introduce two current approaches to understanding complex system behavior, and examine the case for classifying career systems as complex phenomena in the sense that these approaches use. We suggest ways in which these approaches might be used to examine career systems. Finally, we speculate on the paths down which this approach might lead, on the kind of research that might test these speculations, and on some of the difficulties that stand in the way.

## **CAREERS AS COMPLEX SYSTEMS**

### **CAREER SYSTEMS AND CAREER STREAMS**

In this paper we are interested in the dynamic behaviour of career systems. A *career system* comprises a set of work roles and the people occupying the roles, enclosed by a somewhat arbitrary definitional boundary (although some boundary definitions may have more utility than others). These boundaries are arbitrary in the sense that career systems are not concrete entities, but are analytical devices manipulated by the observer. A career system might include, for example, all careers available in the car-making industry, or all careers available within the United Kingdom, or all banking careers located in New York City or all the careers associated with the Lockheed Corporation. For our purposes, we need only assume that career populations of interest can be identified. From this perspective, career systems are well seen as the context for individual careers<sup>1</sup>.

Following Nicholson (1984), we use the term “work role” to denote an individual’s amalgam of employment status and job content. The career system boundary may enclose many kinds of entities, for example an organization, part of an organization, a collection of organizations within a geographical area or an industry sector, or an occupation (Tolbert,

1. We thank an anonymous reviewer for this very clear way of explaining the concept.

1996). Over time one's work roles are created and disappear, and people add and drop these roles from their portfolio of activities. As a result people seem to "move" across the mosaic of work roles enclosed by the boundary, sometimes crossing the boundary in either direction. So the object of interest in a career system is the pattern of movement between work roles and across the boundaries. A career system, as we have defined it here, is open in von Bertalanffy's (1968) sense. There is a constant outflow of people across the boundary as a result of, for example, voluntary departures, transfers, firings, retirements or deaths. For the system to remain viable, then, it needs a corresponding inflow of people to replace these losses (and to feed growth, if any): without constant renewal, it eventually vanishes<sup>2</sup>.

Suppose, for example, the career system we are interested in is that of Company X (i.e., the boundary surrounds Company X). As we have defined it here, the career system is pretty well synonymous with the firm's internal labour market (Doeringer and Piore, 1971): the work roles are defined by the firm's organization chart, and they change as the firm is reorganized. People add and drop roles as their careers develop; they cross the boundary into the career system when they join the firm, and cross the boundary out when they leave. Some of the roles may be temporary, for example those occupied by contract workers, who might also occupy similar roles in other organizational career systems, as occurs in some consulting practices.

Alternatively, a career system boundary could be drawn around an industry, in which case the movement of people *within* the career system will be both *within* and *between* firms, and the creation and destruction of roles can also be the consequence of the birth and death of firms, their mergers and acquisitions, and so on. Silicon Valley provides a particularly vivid example of a mixed *industrial* and *geographical* career system, in which the boundary surrounds an industry sector within a geographical area. In that context, a ferment of creativity results in companies constantly appearing, growing rapidly, and disappearing, generating flows of people between these companies (Saxenian, 1996). These flows are maintained by a continuous influx of young recruits trained in the numerous top universities surrounding the Bay Area (e.g., University of California at Berkeley and Santa Cruz, Stanford University, and the California State Universities in San Francisco, San Jose, and Hayward). Likewise, many seasoned professionals leave the system to pursue careers in associated industries (e.g., high-tech media, engineering, communication, entertainment, etc.).

The patterns of movement recognizable in career systems have been called "career streams" (Gunz and Jalland, 1996a), where specific streams are differentiated by the point of entry and promotion criteria (Sonnenfeld and Peiperl, 1988), the extent to which promotion depends on tournament-like rules (Rosenbaum, 1984; Forbes, 1987), the arenas in which "promotion venturis" (i.e., bottlenecks) crop up (Stewman and Konda, 1983; Stewman, 1986), and the characteristic pattern of vertical, horizontal and diagonal moves which may be found (Gunz, 1989a). Our knowledge of these patterns is surprisingly limited, and many observers believe that the patterns are in a state of consid-

**2.** Our thanks to one reviewer for pointing out that our arguments (particularly those for self-organization) might lead to the impression that «complexity theories are strongly aligned to neo-liberal principles of market forces.» Such was certainly not our intention. As we have noted elsewhere, our usage of the principles of self-organization are strictly meant to explain the dynamics of career system behavior.

erable flux. Yet it is crucial that we do understand them, because they delineate the processes which shape people's work lives and the behaviour of the work organizations and industries with which they are associated (Gunz and Jalland, 1996a).

## CAREERS AND COMPLEX SYSTEMS

At the individual level of analysis the *objective* career is the series of positions that someone holds over the course of their working life, as reported, for example, in their résumé. It is the part of an individual's career that is "visible" to the outside world, and contrasts with the *subjective* career, which is «the moving perspective in which the person sees his life as a whole and interprets the meaning of his various attributes, actions and the things which happen to him» (Hughes, 1937: 409-410). Career systems then, as we have defined them, are patterns of movement of people between jobs within and between organizations; mapping this movement is, in effect, examining a set of objective careers in aggregate.

These patterns in career systems and career streams have traditionally have been thought of as being directed by managers or by individuals developing their own careers (Schein, 1978; Hall, 1986). People are hired, promoted, moved sideways, and fired under managerial control. Similarly, reorganizations, mergers, downsizing, and organizational births and deaths happen because someone decides they should. According to this *voluntaristic* perspective (Astley and Van de Ven, 1983), individuals make career decisions by choosing from a range of options they seek out. In this paper, however, we are attempting something different. We are interested in exploring the extent to which the behaviour of a career system might be a consequence of the *properties that are inherent in the system itself*. This approach is *emergent* because it aims to discover whether there are regularities in the behaviour of career systems that are not the consequence of the *intentions* of individual actors, but instead are a manifestation of the internal dynamics of complex career systems (McKelvey, 1997, 1999). Furthermore, O'Neill (1989) argues that the *dynamics* of systems behaviour can be explained by looking to its component systems (i.e., in our case, individuals), while the functional *meaning* of behaviour can be explained in terms of the system itself (i.e., the career). Long, White and Mathews (2001) have related O'Neill's assertions to Giddens' (1979) structuration theory in which:

«he deals with the recursive and dual nature of society: structure emerges from activities at the interactional level, but structural arrangements inform activities at the individual interactional level. Structure is an abstract framework of relations derived from a cumulative history of action and interaction» (Long, White and Mathews, 2001: 10).

Thus, we should note that an emergence perspective in career systems does not exclude the possibility of voluntarism. It represents a focus on the structure of opportunity (White, 1970) present within a

social setting (here, the career system); but the people making their careers within the career system may still exercise choice as well as affect the system in the way they take advantage of these opportunities (Gunz, 1989b) or avoids its threats (Nicholson, 1996).

We shall describe evidence from research on career system phenomena called "vacancy chains" (the chain of vacancies which ensue when a vacancy crops up in an organization) which suggests that the patterns of occasional upheaval that are typically observed in local labour markets may be a healthy sign that the career system is maintaining itself in a particular state of "self-organization." Research on complex systems suggests that this state is highly desirable, because it permits organizational change and development without everything lapsing into impossible-to-manage chaos (Brown and Eisenhardt, 1997; Anderson, 1999a; 1999b). Our point will be that this behaviour is not the result of a conscious decision on the part of any single individual in the system but rather that career systems may *organize themselves* as a consequence of the way vacancies are filled.

This may sound somewhat mystical, but it is not intended to be: we are not imputing any kind of intentionality to the system. Examples of systems displaying surprising degrees of collective behaviour are well known in the natural world (Gleick, 1987; Waldrop, 1992; Capra, 1996). Scientists have found instances of self-organization in physical systems (Haken, 1977), biochemical systems (Glansdorff and Prigogine, 1971; Eigen and Schuster, 1979), genetics (Kauffman, 1993), and neuro-physiological phenomena (Freeman, 1991; Kahn and Hobson, 1993). Social scientists have also identified numerous instances of self-organizing behavior in diverse contexts such as the emergence of the state (Carniero, 1970; 1987), the evolution of cities and societies (Adams, 1988; Dyke, 1988), economic behavior (Boulding, 1978; Anderson, Arrow and Pines, 1988; Krugman, 1996), and in the development and change of groups (Gersick, 1991; Smith and Gemmill, 1991) and organizations (Leifer, 1989; Lichtenstein, 2000). We shall be arguing that there is evidence to suggest that career systems may be self-organized in a similar way.

To summarize, then, a career system comprises a set of work roles and the people occupying the roles, enclosed by a boundary. The boundary can enclose many different kinds of social systems, e.g., organizational, regional, and industry-wide. We now turn to recent approaches to understanding the behaviour of complex systems, and suggest how they might be used to model career systems.

## **SELF-ORGANIZING DYNAMICS IN CAREERS**

Two approaches to self-organization are useful for understanding career dynamics. The first is termed "self-organized criticality," and is associated with the work of Per Bak and his colleagues (e.g., Bak and Chen, 1991; Bak, 1996). In the modeling of simple systems they identified a complex pattern of self-organization that can also explain the dynamics of earthquakes, ecosystem change, turbulence in fluids, and

stock market behavior, among other diverse phenomena. The second approach was pioneered by Kauffman (1993), whose work on evolutionary biology led to the characterization of an alternative form of self-organized complexity, based on a framework of "NK network" modeling.

## EXPLORING THE STATE OF SELF-ORGANISED CRITICALITY

Through a detailed study of chain reactions in open systems, Bak found that a wide range of dynamic systems naturally order themselves in a state of self-organized criticality (SOC). This state is *self-organized* because systems appear to move into it spontaneously, without intervention on the part of any system agents. The term *criticality*, which comes from physics and physical chemistry, is a condition that lies on a transition boundary between two more stable states.

The fundamental hypothesis in SOC research is that the chain reactions characterizing these systems follow a *power-law distribution*. Probably the best-known example of power law behaviour in nature is the Gutenberg-Richter law, which describes the distribution of the energy released by earthquakes (Winslow, 1997). Within a given geographical zone, earthquakes follow a power law distribution: if the logarithm of the energy released by an earthquake is plotted against the logarithm of the frequency of earthquakes of that size, a straight line results; put more crudely, there are few large earthquakes and many small ones. This, supporters of the SOC concept argue, is evidence that the earth's crust evolves to a state of SOC (Bak and Chen, 1991).

SOC can be illustrated through the well-known sandpile experiment (Bak and Chen, 1991). A steady stream of sand grains is dropped onto a disk of a certain size. Gradually the sandpile builds up until some of the sand begins falling off the edge. At some point the sandpile will stop growing because, on average, as much sand is falling off the disk as is being added. The pile has now reached a *critical state*. Whenever too much sand ends up on the pile, it becomes *supercritical*, and collapses to its critical state again. In this state of SOC the behaviour of the pile as a whole is predictable: overall, the sandpile will maintain its slope. But the fate of individual sand particles as they are added to the pile is much less predictable. Some of the individual grains will stay where they land. In other cases, a falling grain will displace other grains which, in turn, displace yet others, creating a mini-avalanche that cascades down the side of the pile. Most of these avalanches are small, but every so often one occurs that is much larger. Thus, although sand is being added at a uniform rate to the top of the pile, it falls off the bottom in a series of avalanches varying in size. Over the long term, the size of these avalanches follows a power law distribution (Bak, 1996).

The power law behaviour of these systems has an important implication for dynamic systems of many types, namely: *large events are rare, but normal*. Everyone is familiar with the way active earthquake areas



produce many small quakes and, every so often, a massive one; this is the behaviour described by the Gutenberg-Richter law. In a metaphorical sense, if career systems were to display this power law behaviour, they would exhibit a continual series of small chains of events (we return below to consider what these chains of events might be), and, every so often, a large one. Similarly, Bak and Sneppen (1993), in their discussion of the power law behaviour of species extinctions in the fossil record, point out that SOC does not exclude the possibility that large cataclysmic events (such as the impact of a massive meteorite) may be responsible for extinctions. The important implication, however, is that these cataclysmic events, like large avalanches on the sandpile, *are a normal aspect of the system's dynamics*. Although it is not possible to predict precisely when these large changes will happen, they are a completely expectable result of the self-organizing dynamics of the complex system. So while it is natural to try to find an explanation for a massive event, whether it be a major earthquake, a catastrophic species extinction, or a major upheaval in a career system, it may be that there is no explanation per se, other than to recognize the internal, emergent dynamics of such systems that have evolved to the "edge of chaos." In the next section we consider what these chains of events might mean in the context of career systems, and what might be driving them.

## THE DYNAMICS OF SELF-ORGANISATION IN CAREER SYSTEMS

Two basic components can be used to explain SOC in physical systems and career systems. *Drivers* are the inputs that increase stress within the system; and *stress-relieving chain reactions* are the system's way of maintaining itself in a stable, self-organized state. To return to our examples in physical systems, the driver for SOC in a sandpile is the steady input of grains of sand to the pile, and the driver for SOC in an earthquake zone is the relative movement of tectonic plates (**Table 1**).

**Table 1.** Drivers and Stress Relievers  
in Self-Organized Criticality

	Sandpile	Earthquake zone	Career system
Driver	Sand grains being added	Tectonic plate movements	Loss of people from career system, changes in work roles
Stress-relieving chain reaction	Avalanches of sand grains	Slippage of one part of crust past another, i.e., an earthquake	Vacancy chains (e.g. turnover, layoffs, new jobs/roles)
Catastrophe (if stress was not relieved)	Supercriticality: Collapse of pile	Catastrophic reconfiguration of the earth's crust	Organizational failure; major upheaval of labour market



As we explained above, sandpiles relieve the build-up of system stress through occasional avalanches of sand grains, just as earthquakes are a chain reaction of movements in the earth's crust which relieve geological stresses caused by tectonic plate motion. So what might the equivalent drivers and stress-relieving chain reactions be in career systems?

We defined a career system as a set of work roles and the people occupying the roles, enclosed by a boundary. In general terms, then, change in career systems consists of people joining and leaving the system, people moving from one role to another, people adding or dropping roles from their portfolios of activity, and roles appearing and disappearing. For simplicity we shall consider here only situations in which 1/ each person occupies no more than one role, and 2/ each role can only support only one person. Real life is more complicated than this, of course. In practice it is possible for someone to occupy more than one role if the roles are, for example, the project-based activities of a freelance professional, and there is also a variety of innovative ways of sharing roles. However, our simplification is not a bad approximation to reality.

The simplification allows us to make a number of statements about career systems. First, a person can only be in the career system if there is a role for them to fill. Second, they can only move from one role to another (for example in order to be promoted) if there are vacant roles for them to move to. Third, if a person leaves the career system (for example by retiring, dying, or joining another career system) they create a vacancy that someone can fill from within the career system, or from outside the system. Fourth, when a role is created an opportunity for movement is also created by virtue of the vacancy that the new role generates. Finally, the elimination of a role forces the role incumbent to move to another role, either inside or outside the career system.

This simplified model of a career system underpins a stream of research deriving from that of White (1970), based on the concept of the "vacancy chain." According to this research, there are two logically equivalent ways to view mobility within a labour market (White, 1970; Stewman, 1986), 1/ by tracking the movement of people from role to role, and 2/ by tracking the "movement" of the vacancies that are created as people leave roles. Most research in this area has adopted the latter, vacancy chain perspective, and we shall adopt it here.

A chain begins when a vacancy is created in a career system, perhaps by someone retiring, being fired, or by a shift in work roles. If the vacancy is filled from within the career system, a new vacancy is created, and the chain continues. As a simple example, imagine the career system in a consumer products firm (i.e., the career system boundary surrounds the firm). The vacancy chain is initiated when the CEO retires. The VP Marketing may be promoted to fill the vacancy left by the departed CEO, creating a vacancy for a VP Marketing. The vacancy propagates itself through the career system until it is either filled by importing someone across the career system boundary, or the position is eliminated. The vacancy chain might equally have been terminated through a reorganization that combined two positions; indeed, reorga-

nizations have been found to be a common method for terminating vacancy chains (Pinfield, 1995). Vacancy chains have been studied amongst clergymen (White, 1970), public school administrators (Brown, 1975), police managers (Stewman, 1975a, 1975b) and forest product managers (Pinfield, 1995).

The vacancy chain perspective focuses on the drivers within career systems, and on stress-releasing chain reactions. Two main kinds of process emerge as potential drivers to increase stress in career systems: 1/ people leaving the career system, and 2/ work roles being restructured. Vacancies are created when people leave the career system, and through reorganizations in which roles are created, for example as a result of organizational growth. Too many vacancies can create a stress condition within the career system: if there are not enough trained people to do the work, life becomes very stressful for those who are still in the system. But restructuring can also result in fewer work roles, and downsizing is a well-documented source of stress within career systems. In knowledge-based industries like film and software engineering (Jones, 1996), work roles are created when new project ventures require staffing with contingent labor; these roles are then eliminated at the project's completion (Matusik and Hill, 1998).

Vacancy chains are the potential *stress-relieving chain reaction*. When stresses build up in the kinds of way we have just outlined, they are relieved by a series of personnel moves. A build-up of vacancies, for example, can trigger a number of chains of events. In addition to the obvious, a wave of recruitment, jobs may be reorganized to reduce the need for people, or people may be moved in from other parts of the organization, and each course of action has the potential to set off further vacancy chains. In each case what we are describing are situations in which a vacancy chain relieves the stresses created by the personnel shortage. In some cases the chain may be short—a vacancy which is filled from outside has a length of one; in other cases it may be long, as might be the situation if a complex set of personnel moves flow from the decision to call on other parts of the organization to help. The issue, however, is not the specific cause of each chain, but the internal emergent dynamics of all the chains within the career system. Like earthquake zones, whose internal dynamics exhibit power-law behavior, we would posit that the dynamics of career-level vacancy chains may also exhibit power law behavior, and thus be internally organized, or self-organized. According to this hypothesis, if the distribution of the lengths of the vacancy chains follows a power law distribution, the career system in question may be in a state of Self-Organized Criticality. Next, we reanalyze published data to see if this power law phenomena is evident in career systems.

## EVIDENCE OF SOC IN CAREER SYSTEMS

The average length of vacancy chains tends to be low, often around three (White, 1970; Stewman, 1986; Pinfield, 1995). Vacancy chains are very difficult to measure, requiring either excellent published data or

a high level of access to a company's operations. White's team of researchers carefully combed through the published records of three American churches (the Episcopalian, Methodist and Presbyterian), recording movements of ministers from one congregation to the next. Pinfield's team interviewed the managers of a forest products company ("Forestco") who made staffing decisions, tracing chains of moves forwards and backwards, as well as using the company's personnel records to trace all the personnel moves they could find. So the career system boundaries in question surrounded each of the three churches in White's study, and surrounded Forestco in Pinfield's study.

Chain length distributions were published by White (1970) for the Episcopalian and Presbyterian data, and by Pinfield (1995) for all chains he identified (**Table 2**). Log-log plots of chain length against frequency of chain (**Figure 1**) do suggest a power law relationship, because this relationship between chain length and number of chain events of each length, if plotted on a log-log graph, should reveal a straight line (Bak and Chen, 1991). As **Figure 1** shows, these vacancy chains do indeed show power law relationships. Markov chain modeling (White, 1970: 23-24) also predicts that if the probability that a vacancy chain is terminated is the same at each step along the chain, then a power law should be the result. Note that in these data the shortest chain lengths in some cases are a little under-represented. These are, methodologically, the hardest to detect because they are completed in the shortest time and so for example may be missed when year-by-year personnel records are being compared; this may provide at least some of the explanation for the convexity of the lines in **Figure 1**.

If indeed power law behaviour is an indication of SOC, then these data suggest that the careers systems studied by White and Pinfield have evolved into this adaptive state. It is certainly intriguing that vacancy chain length distributions from such different organizations with such

**Table 2.** White (1970) and Pinfield (1995) vacancy chain length distributions

Vacancy chain length	Frequency distributions			
	Episcopalian 5 decades	White		Pinfield Forest Service Late 1980s
		1922-23	Presbyterian 1959-60	
1	53.31	49.3	49.8	—
2	27.39	19.4	23.0	68
3	8.15	18.7	15.5	48
4	5.44	2.9	4.7	28
5	1.75	5.3	3.6	10
6	2.01	1.6	2.4	10
7	0.98	0.9	0.6	3
8	0.38	0.0	0.0	3
9	0.33	0.8	0.5	2
10	0.17	1.2	0.0	—
11	0.00	—	—	—
12	0.09	—	—	—

different kinds of hierarchy, over such a broad length of time (from 1912 until the late 1980s), should display such similar characteristics to each other.

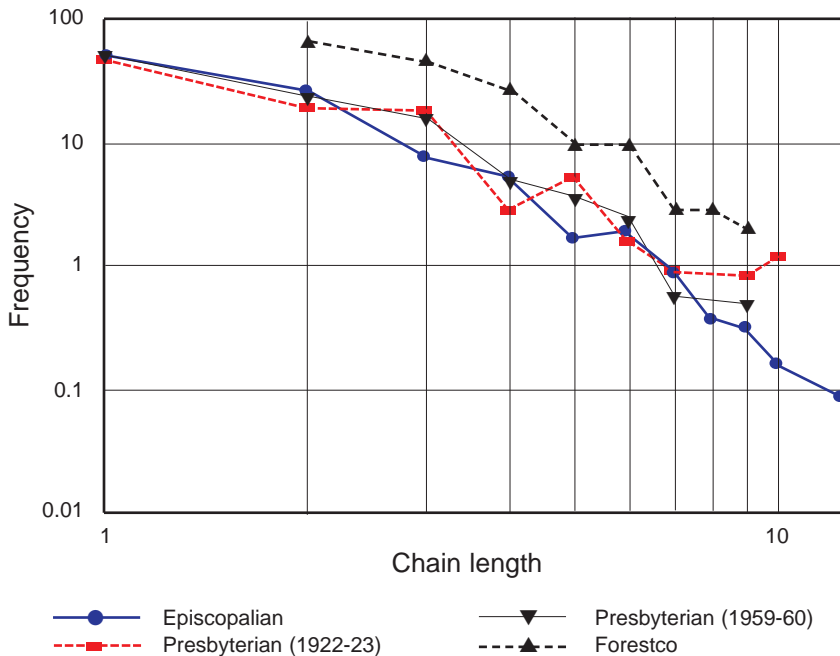
To summarize, data from studies of vacancy chains are consistent with the hypothesis that at least some career systems are in a state of SOC. But the studies we have reviewed were of bounded, organizational labour markets. It remains to be seen whether more fluid, boundaryless career systems exhibit the same behaviour, and there is a great deal more work needed to identify the interconnectedness of vacancy chains before we can state with any confidence that career systems really do show SOC.

Thus far, we have discussed what the drivers of SOC are and *how* they seem to operate in career systems. The final issue we want to explore is *why* these mechanisms seem to operate in career systems. Why might vacancy chains follow a power law distribution? The answer may be found in the complexity study of NK networks, which we turn to next.

## CAREERS AS AN ADAPTIVE NETWORK

### A DESCRIPTION OF NK NETWORKS

In the previous section we showed that the distribution of vacancy chain lengths in two published studies approximated to a power law, suggesting that the career systems might be in a state of SOC. But we said noth-



**Figure 1.** Log-log plots of vacancy chain distributions

ing about what might cause the vacancy chains to follow this distribution. Next, we shall argue a tentative case that so-called NK network modeling may provide a way of looking inside this black box. We believe that career systems can be modeled as an adaptive network, described by Kauffman (1993, 1995) and others in terms of an NK network (Levinthal, 1997; Levinthal and Warglien, 1999; McKelvey, 1999).

An NK network consists of  $N$  nodes, each of which is acting on other nodes in the network. Each node is connected to a certain number  $K$  of other nodes. So, for example if  $K = 1$ , each node receives input from one other node; if  $K = 4$  the network would resemble a simple fishnet. The most interconnected situation would occur if  $K = N$ , where each node receives input from every other node as well as from itself; this situation can overload the system, forcing it into a state that is chaotic and unpredictable (See **Appendix** for details).

Kauffman (1995) extends the NK model to show how it can be used to analyze the overall fitness of the system. He uses so-called *fitness landscapes*, which are familiar to biologists as a way of modeling a system's fitness. Each point on the landscape represents a particular combination of the system's state variables, and the higher the "altitude" of that point on the landscape, the fitter the system. Fitness is defined in a way appropriate to the system; for an organism, it typically means its fitness in terms of natural selection processes. Let us define "fitness" for our observer defined career system as *the overall fit between people and work roles within the career system*. For example, a career system with a well-organized set of work roles that are filled with people who relate well to their colleagues are who well suited to their tasks, is in a high-fitness state.

A fitness landscape which is flat and featureless describes a system whose fitness does not change much, if at all. For example, if a career system had this kind of landscape the implication is that there is no way to distinguish between any arrangement of people and roles within the system: any arrangement is pretty much as good (i.e., as fit) as any other. By contrast, a rugged fitness landscape with sharp peaks and deep valleys describes a situation in which changing the system's state variables, even slightly, makes a great deal of difference to its overall fitness. Again, if a career system had this kind of fitness landscape the implication is that it makes a very great difference to its overall fitness if even small changes are made to the allocation of people between roles. One small change might improve things dramatically (i.e., by moving the system up a high peak) or make them drastically worse (by plunging it into a deep valley).

Kauffman (1995) shows how these landscape features vary with  $K$  or the number of information sources connected to a particular node. Networks with low values of  $K$  (e.g.,  $K = 1$ ) have smooth fitness landscapes with few peaks. These systems are "frozen;" they have very few directions toward which they can evolve and a limited number of ideal states. This makes  $K = 1$  (simple/stable) systems non-adaptive and vulnerable to ecological change. In contrast, NK networks with high values of  $K$  (complex/unstable) are highly chaotic and unpredictable. Their landscapes are very "rugged," so that any change yields

essentially random results: it might result in a dramatic increase in fitness or an even more drastic decrease in fitness, and because the peaks and valleys are so sharp, the next move will be equally unpredictable in its outcome.

Kauffman found that NK landscapes with low (but greater than 1) values of  $K$  exhibit particular advantages. They have a few peaks clustered together, so change is more predictable and it becomes more possible for the system to improve its fitness. Indeed when  $K = 2$  a remarkable amount of order is observed in a binary NK network (a network in which the behaviour of the nodes is governed by simple Boolean rules), regardless of the number of nodes (see **Appendix**). Kauffman calls this  $K = 2$  orderly behaviour "order for free", because it is an intrinsic (emergent) property of the network. Next, we consider its possibilities for modeling career systems.

## CAREER SYSTEMS AS AN NK NETWORK

Let us revisualize a career system as an NK network in which each of the  $N$  nodes represent  $N$  specific work roles. In order to understand what  $K$  might mean in this context, we need to shift from the organizational perspective of vacancy chains to the individual perspective of vacancy-filling processes.

People are constantly moving through the system as vacancy chains get started and terminated. When a vacancy occurs, a search process is instituted to fill it. Let us define  $K$  as the average number of *realistic* possible sources that are considered by human resources (HR) managers and other searchers who are trying to fill the vacancy. The realism condition is important because people typically are capable of coming up with a broad range of potential sources, although they seriously consider only a few of these (Gunz and Jalland, 1996b). In one case the search may be extremely straightforward; for example, everybody knows that there is only one candidate for the job, and she gets it: end of search. Here,  $K = 1$ . Alternatively, the search may be quite complex: the searchers may cast their net very widely and consider candidates from an extremely broad range of possibilities;  $K$  here would be a much larger number<sup>3</sup>.

As mentioned above, NK networks with  $K = 1$  are highly predictable but unadaptive. It seems likely that the  $K = 1$  career system is of this nature. Vacancies that occur in the career system are filled predictably and systematically, yielding very little change throughout the system. A family firm in which everyone knows that each position has one and one only potential successor (e.g., everyone knows that the eldest daughter will succeed her father when he retires) is an example of a  $K = 1$  career system. In this case, the limited searches make it unlikely that the best, or anything approaching the best, candidates are being placed in each work role as it falls vacant. In our apocryphal family firm, for example, the eldest daughter may be the worst possible choice for the top job. As a result, it is highly unlikely that the overall fitness of the career system will reach an optimal state.

**3.** A reviewer made the interesting suggestion that firms could also be considered as elements in an NK network, such that  $N$  is the number of employing organizations, each of which may employ more or fewer people, and  $K$  is the number of alternative employment opportunities realistically reachable from each firm. We have not explored this possibility in this paper because the change in level of analysis would require considerably more space; but we are intrigued by its potential.



NK networks with large values of  $K$  behave chaotically (Kauffman, 1993). What would a high- $K$  career systems look like? Imagine an organization or industry in which every work role has a nearly unlimited number of successors. In this case, the occupants of work roles are highly aware of all potential vacancies, and their day-to-day behaviour is likely to be negatively affected through anticipatory socialization and all the myriad political games that are played as people try to manage their career prospects. The more interconnected this career network becomes, the more havoc these political games play for individuals and their organizations. Moreover, these competitive games intensify when a work role falls vacant, as people jockey to be considered for that role. If the overall level of interconnectivity is too high, such as in a very rugged NK landscape, the system can collapse into chaos. In this case, a vacancy chain in a too highly interconnected system would result in either major improvement or major decline, and it will be virtually impossible to predict which of these outcomes is the more probable. The resulting outcomes can have unpredictable, even chaotic results on the behaviors of those who were not chosen. This would be a highly unadaptive situation indeed.

The vacancy chain data we reviewed above suggest that career systems may settle in an intermediate position between unadaptive and chaotic states, namely a state of Self-Organized Criticality. Given that low values of  $K$  result in non-adaptive, frozen system states, and very high levels of  $K$  result in chaotic systems, we suggest that well-adapted career systems have values of  $K$  that are not very large. How might we conceptualize  $K$  in practice?

According to our definition of  $K$ , two versions of the parameter can be identified: 1/ the number of sources for each position that might be formally considered for a vacancy, i.e., as defined by a formal succession planning system are denoted "formal  $K$ " or  $K_f$ , and 2/ the number of actual sources that are considered when a job falls vacant as "informal  $K$ " or  $K_i$ . As any HR manager will attest, it is much more difficult than it seems to maintain the substantial slate of candidates for each managerial job, especially key posts, that a well-run succession planning system requires (see, e.g., Hall and Goodale, 1986: 403-405). Moreover, even if it is possible to compile some or all of the slates, by the time they are needed they are likely to be out of date because it is just as time-consuming to maintain them as it is to construct them in the first place. Based on practical considerations such as these, as well as the normal limits to cognition that one expects to encounter,  $K_f$  might be limited in size, even in well-run organizations.

Given this distinction, what values might be found in practice? Senior managers often report that they try to have three candidates for each senior post, suggesting that typically, at most,  $K_f = 3$ .  $K_i$  is likely to be different, because it is the number of people who are *actually* considered, who may or may not be on the formal succession slate for the position. It could be higher than  $K_f$  if, for example, the position is an important one and there is a great deal of interest in it. However, given that we defined  $K$  as the number of positions *seriously* considered, and given normal limits on managers' time, pressures to act, and limits to



cognition, it would not be surprising if  $K_i$  were lower than this. So although we have no direct evidence, it would not be surprising if  $K$  were in the 2-3 range, which could provide the necessary condition for self-organization. This result is remarkably close to the results found by Kauffman.

To summarize, NK network modeling suggests an alternative way of viewing career systems, in terms of the number of roles within the system ( $N$ ) and the average number of people ( $K$ ) considered for vacancies when they occur. Work on binary NK network models suggests that for very low values of  $K$ , the career system may respond so sluggishly to the drivers of change that the overall fitness of the system will suffer: too many people will be in the wrong jobs. By contrast, high values of  $K$  will result in chaotic situations in which any change triggers wide-reaching and unpredictable upheavals. The intermediate state of SOC, which for binary NK networks appears to be where  $K = 2$ , may be a situation in which the career system is able to respond to change without lapsing into chaos. If so, then there are some fascinating questions that can be asked about the behaviour of career systems in this state, to which we turn.

## DISCUSSION

We have explored some ideas from the field of complexity theory, and shown their applicability to the study of career systems. Many natural systems evolve into a state which has been called self-organized criticality. Systems maintain themselves in a state of SOC by means of chain reactions which follow a power law distribution: they are mostly small but occasionally are large. By defining a career system in terms of movements across a stream of work roles, we showed that vacancy chains from some previously published studies approximate to this power law behaviour. This result, which is also predicted by Markov chain analysis, suggests that career systems can evolve into a state of SOC.

Next, we drew on NK networks to analyze the mechanisms underlying this apparent self-organized behavior. Because our aim is speculative we have limited ourselves to showing that there are features of career systems that resemble NK binary networks, suggesting a potentially fruitful approach to analyzing them. We now turn to the question: What might this mean in practice?

First, our complexity perspective changes the way one might view major labour market upheavals. Systems in a state of SOC appear to maintain themselves in that condition through a series of chain reactions, most small but some large. If a career system is in this state, we can expect periodic dramatic upheavals, albeit at rare intervals but without any particular reason for them to happen other than chance. Anecdotally, this does seem to match well with experience: labour markets do, every so often, seem suddenly to get very active as an unusually large number of people shuffle between jobs. As one example, a Japanese bank has a well-designed succession management system,

but every so often there appears to be great upheaval and confusion at senior levels (Bird, 1997). It turns out that at the level below the board,  $K$  is comparatively high because there are several potential routes to top management, and this was found to be the source of the movement (Bird, 1997). Yet, far from being an indication of trouble, these periodic large-scale chain reactions in a labour market can be seen as a signal that the system is adjusting well to change and is maintaining itself in a healthy state.

A second implication relates to the close relationship between career systems and organizational change processes. Pinfield's (1995) findings are consistent with the conclusion that the distribution of vacancy chain lengths, with a high proportion of short chains, is closely linked to processes of organizational change and renewal: «if job structures are in a modest state of flux, and vacancies are used as opportunities to reorganize, vacancy chains will exhibit predominantly short lengths [making internal labour markets] responsive and adaptive to environmental change» (Pinfield, 1995: 21). Forestco had been undergoing substantial reorientation and reorganization, and he found that chains were often terminated by a re-organization. White's organizations were, not surprisingly, more stable, but even in churches congregations were merged or split, terminating or generating vacancy chains.

Avalanches of movement provide opportunities for organizational change as work roles become detached from the people who have personal investments in their maintenance. A career system in the frozen state, which may turn out to be, for example, the consequence of  $K = 1$ , has little potential for organizational change because it is a system which, by definition, has few possibilities for innovating when it comes to finding new role incumbents. Even with  $K = 1$ , of course, work roles can be removed, set up, combined or split, but the rigidity of the career system reduces decision-makers' freedom to find creative staffing solutions for the new mosaic.

On the other hand, a high  $K$  career system implies that there are far fewer constraints to organizational change, and perhaps too much room for creativity. High values of  $K$  imply that the searches to fill vacancies will be very broad, which can initiate a chain of events with unpredictable impacts on the overall career system and the way the mosaic of work roles operates. For example, imagine a team developing an important new product. How difficult it would be to maintain a sense of direction when, every time a vacancy crops up or a reorganization happens elsewhere in the firm, every member of the team becomes vulnerable to becoming swept up in the personnel movements that ensue.

The intermediate SOC condition, with  $K$  at a lower number but greater than 1, avoids these uncomfortable extremes. Change is matched by a moderately wide search to find the most appropriate people to fill roles. The power law distribution of vacancy chains—there are many short chains and a few long ones—implies that disturbances initiated by change in one part of the work role mosaic typically leave most of the rest of the mosaic undisturbed. In other words, career systems in this state do not respond chaotically to change. Furthermore, our brief

review of adaptability of fitness landscapes suggests that it is easier for a low-K system's fitness to improve in response to change than it is for high-K situations, in which the outcome is much less predictable.

Thus, a major implication of exploring career systems from a self-organizing perspective is that the state of SOC might confer a high degree of adaptability within the system, being adaptive to external changes without lapsing into predictable stability or unpredictable chaos. This intuitive result appears warranted from a careers perspective. For example, the turbulence that most organizations are experiencing (and, most observers argue, will continue to experience) makes the  $K = 1$  state unlikely to be stable in the medium term. Likewise, it is easy to imagine that chaotic career systems are so unsettling to their occupants that they are naturally avoided (Nicholson, 1996). If these assumptions are correct, it follows that the SOC condition may well be stable for career systems in periods of long-term organizational and industrial change.

## IMPLICATIONS FOR STRATEGIC HR MANAGEMENT

What are the implications of career systems being in a state of SOC? We consider two: those of the power law distribution of vacancy chain lengths, and of the system's tendency to remain adaptive.

The observation that vacancy chain lengths follow a power law distribution implies that a career system which, for most of the time, experiences fairly short vacancy chains will, sometimes and unpredictably, experience a long one. Why should this be of interest? First, traditional views of HR management readily build up a picture of a well-managed career system as one in which people move smoothly and predictably across the mosaic of work roles. To be sure, examples of uncharacteristically large upheavals are familiar, for example, a mass exodus of talent that sometimes overtakes high-technology companies when opportunities emerge elsewhere, a difficult succession process that spreads its tentacles much further through the firm than anyone expected, or an industry-wide reorganization that can affect tens of thousands of jobs across multiple organizations. Typically these major changes are taken as signals that something has gone terribly wrong, especially if nothing like them has happened for some time; and, indeed, they can be extremely disorienting and distressing for the people swept up in them. But according to the hypothesis of SOC, large-scale avalanches mean that the system is adjusting itself to change in a normal and healthy way. In other words, we should expect a career system to respond to the drivers of losing people and reorganization with a series of vacancy chains of varying length, mainly short but a few long, following a power law distribution.

Second, we return to the boundaryless hypothesis in careers (i.e., careers are not limited by a single organization or industry) and to recent work by Kauffman and his colleagues (Kauffman, 1995: 252-264). Very briefly, they explored the impact of dividing the NK network into "patches" of nodes in which the behaviour of individual nodes is

governed by their impact on the patch to which they belong, rather than their impact on the network as a whole. It turns out that for high values of  $K$ , chaos can be avoided by dividing the network into patches of a given size (which varies with  $K$ ). This finding raises the intriguing possibility that in highly interconnected career networks (e.g., project-based networks of geographically-based industries), chaos can be avoided by re-inventing the boundaries of the networks, by re-establishing the scope of the career system. (See Gunz, Evans and Jalland, 2000).

## **FUTURE DIRECTIONS**

Our aim in this paper has been speculative: is it possible to use ideas from the emerging science of complexity to gain new insights into the behaviour of career systems? We have demonstrated that some career systems appear to display a key feature of self-organization, namely a power law distribution of vacancy chains, and we have explored some of the implications of this outcome. Yet a great deal of work needs to be done to validate and explore our speculations. There are several initial approaches that could be taken, and we conclude by briefly referring to a few.

Although published studies of vacancy chains are rare, it may be possible to undertake further secondary analysis of data on career change in different industries in order to look for further evidence of power-law distributions. More probably, longitudinal analysis of labour markets will be needed to investigate branching processes of different kinds, their causal factors (that is, the processes underlying the avalanches of change that we argue here are responsible for driving SOC in labour markets), and their frequencies. This might allow us to study the ways in which the exponent of the power law may change over time. In this way some sense of the evolution of industry dynamics may be indicated, as well as the pace of such changes in the long term. Such a comparative method might bring us closer to being able to establish whether some labour markets are more self-organized than others, and in which ways.

If vacancy chains are the key to self-organization, then we need to consider the meaning of the concept in the context of the mosaic of work roles which we have used here to conceptualize career systems. Can they be viewed more broadly, and if so, might career systems be even more explainable in terms of self-organized criticality.

We have described vacancy chain analysis in terms of one-to-one chains: a vacancy is created, someone fills it, creating a second vacancy, and so on. But this is clearly an oversimplification. White (1970: 59) identified compound vacancy chains: sometimes when an incumbent leaves a compound job, it is split, and different people are the replacements in different congregations. The result is a compound vacancy chain. White traced what he termed the main vacancy chain, which normally ran through the largest congregation, and treated the subsidiary chains separately. But it could be argued that if we are

examining career systems for the analogue of the sandpile avalanche or earthquake, we should treat the compound chain as a single phenomenon rather than breaking it into main and subsidiary chains. Indeed, there are at least three other common labour market phenomena which cause more complex branching processes which, in turn, may trigger larger avalanches which are invisible if only one-to-one chains are being examined.

First, when a senior figure such as a CEO leaves and the position is filled, for example by a senior VP, it is not unknown for some of the unsuccessful senior VPs to resign in the knowledge that their chances of becoming CEO are now greater elsewhere: one initial vacancy (created by the departing CEO) has created several vacancies at the VP level. Second, senior managers hired away by a competitor will occasionally take several of their protégés with them; similarly, executives who start their own companies in a boundaryless industry often choose partners from informal networks or previous contacts in other jobs (Saxenian, 1996). Third, a few people leaving an organization, especially if they were all in the same job category, can sometimes unsettle their former colleagues to the point at which many more leave. Similarly, if the labour market in question spans a geographical region, it is possible to imagine complex cascades of moves, as firms start up and draw in labour from surrounding firms (Saxenian, 1996) which, as a result, may experience decline and lay off more people, as firms close down putting people on the labour market, depressing local economic conditions and putting yet more people out of work, and so on.

So a rewarding further direction for empirical work might be to explore the nature of vacancy chains in this broader sense, in answer to the question: have we been missing something which might help us understand the adaptive behaviour of career systems? We do not mean to imply that the examples we gave in the previous paragraph are particularly common, but the possibility should at least be entertained that it is valid to regard them as linked events. If so, then it might be that the slight convexity that we noted in some of the log-log plots of vacancy chains (**Figure 1**) might be reduced at the long chain end as well.

We have hypothesized that there is a parameter  $K$ , which we suggested might be observed in two variants, formal  $K_f$  and informal  $K_i$ , and which should be a predictor of whether career systems are in a frozen, self-organized critical, or chaotic state. It may be possible to design a cross-sectional study to test this hypothesis.  $K$  should be measurable in a variety of ways: by means of interviewing managers involved in search processes, questionnaire instruments, reviewing HR succession planning data, HR policies, and observational studies. Outcome measures may be more difficult to define. Ideally they would include vacancy chain data, but this may well be impractical in a cross-sectional study. Alternative data sources could include total numbers of personnel moves and their distribution across the organization, and perceptual data on the impact of vacancies across the organization and the stability of the career system.

It would be interesting to try to adapt the modeling approaches used in studies of SOC in other kinds of system to help answer the question of whether and how the adaptability of organizations and industries may vary with parameters such as  $K$  and the decision rules governing vacancy-filling processes (the analogue of the Boolean rules of NK networks). What kind of combinations of parameters, if any, might generate self-organizing behaviour in model career systems, and what practical implications would these combinations have for succession management? What limits are there to boundarylessness in labour markets in which search behaviour is of any real complexity?

We do not wish to minimize the difficulty of the kind of research we envisage. Vacancy chains are time-consuming and resource-intensive to study, and need either excellent published data of a kind which conventional published sources simply do not make available, or a high level of access either to detailed personnel records or to the people behind the records. In addition, many of our predictions imply the need to be able to measure career system fitness, which will need some care to operationalize.

When ideas are being transplanted from one field to another it is always hard to know whether something new is being said or whether one has simply found new words to describe an old problem. Of course it sometimes happens that even though nothing new has been said, the new constructs invoke metaphors that invigorate creativity. But the question remains: have we simply relabeled old career issues in new complexity bottles, or have we identified a genuinely new way of viewing career phenomena?

We believe that the approach we have outlined does suggest a new way of approaching the analysis of career system behaviour. If it is the case that career systems have innate properties which draw them into a state which is not only stable over the medium term but creates an environment conducive to organizational change, and that this emerges spontaneously and not as a result of conscious managerial decision-making, then we should be able to detect the processes that underlie this self-organization. Whether they turn out to be vacancy chains governed by power law behaviour, and whether or not there is a parameter we have called here  $K$  that plays a part, remains speculative at this stage. But the implications of self-organization in career systems for ideas of human agency are too fascinating to leave uninvestigated.

**Hugh P. Gunz** trained as a chemist in New Zealand, and has PhDs in Chemistry and Organizational Behaviour. His career started in the petrochemical industry, and he has taught on the faculties of Manchester Business School and the University of Toronto's Joseph L Rotman School of Management, where he is Professor of Organizational Behaviour. He has published papers on the careers of managers, professionals and others, the management of technical professionals, and management education. He is the author of the book *Careers and Corporate Cultures*, published by Basil Blackwell. His research interests include the structure of managerial careers in and between organizations and their impact on firms' strategic management, the application of complexity science to careers, and ethical dilemmas experienced by employed professionals.



**Benjamin M. Bergmann Lichtenstein** is an Assistant Professor of Entrepreneurship and Management at the Barney School of Business, University of Hartford. His entrepreneurship research focuses on the emergence of new firms, learning in new companies, and major transformations in small business. Benjamin is exploring unique approaches to entrepreneurial resource acquisition and leveraging competencies for new business growth. As director of the Entrepreneurial Studies program at the Barney School, Benjamin has dramatically expanded participation in the major over the past three years, and has helped several students get into business themselves.

**Rebecca G. Long** is an Associate Professor of Management at Mississippi State University. She received her Ph.D. from Louisiana State University. Her largest current research interests center around the complexity sciences and their theoretical and methodological uses in organization studies. Her other interests lie in the areas of employee mobility and advancement, externalization of labor, and strategic human resources management. She has had publications in such journals as the *Academy of Management Journal*, *Organization Research Methods*, *Journal of Management*, *Human Relations*, *Journal of Management Inquiry*, *Advances in Industrial & Labor Relations* and *Group & Organization Management*.

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## APPENDIX: FITNESS LANDSCAPES

The behaviour of each node in the NK network is governed by some kind of algorithm describing how it responds to different combinations of inputs. The simplest version (Kauffman, 1993) specifies that all inputs are binary (i.e., they take the value either of 1 or 0), and that each node's behaviour is governed by Boolean rules. So, for example, a node in a  $K = 2$  network might follow an "if" logic: it generates a 1 if it is receiving a 1 from either or both of its inputs. Obviously, for a  $K = N$  network (assuming  $N$  is any size at all), the Boolean rules for each node would be extremely complex.

Kauffman used computer discrete event simulations to study the behaviour of these NK networks. Imagine a  $K = N$  network with its nodes in an arbitrary arrangement of states: because the network is binary, each node is either "on" or "off". Consider what happens after an imaginary tick of the clock. Each node examines its inputs and applies its Boolean rules to them, remaining in the same state, or changing from "on" to "off" or *vice versa*, as its rules specify. Each node then sends the output of this computation to every other node it is connected to, including itself. Next, each node examines the new inputs, and repeats the process.

Eventually the network will return to its original state, having followed a path of changes Kauffman calls its state cycle. But for a network with only 200 nodes, the state cycle is somewhat long: it has of the order of  $10^{30}$  states (Kauffman, 1995: 82). Even if the network took only a microsecond to pass from state to state it would take billions of times the life of the universe to traverse the complete cycle. Its behaviour is clearly chaotic, because although it is governed by deterministic, Boolean rules, for all practical purposes it is random: it will never be

observed to follow the same path twice. At the opposite end of the complexity scale, however,  $K = 1$  networks do nothing of any interest: very quickly, they reach a frozen state and remain there.

If we were to flip one node in a  $K = N$  network, over-riding the Boolean rules it is following, the system will probably be pushed into a different state cycle, of which there are  $N/e$  in a  $K = N$  network. Of course, with 1030 states in either cycle we would never know that this has happened: the network's behaviour would seem as random as before. On the other hand, if we were to do this to a  $K = 1$  network, we would see it settle very quickly into a new pattern and stay there.

Kauffman (1995) extends the NK model to show how it can be used to analyze the overall fitness of the system. He uses so-called *fitness landscapes*, which are familiar to biologists as a means of conceptualizing the way a system's fitness varies as its key variables vary. Each point on the landscape represents a particular state of the system (i.e., a particular combination of its state variables), and the higher the "altitude" of that point on the landscape, the fitter the system. Fitness is defined in a way appropriate to the system; for an organism, it typically means its fitness in terms of natural selection processes. Space does not allow a full account of fitness landscapes: here, we shall focus on two features of landscapes, their "ruggedness" and the arrangement of their peaks.

Kauffman (1995) shows how these features vary with  $K$ . NK networks with high values of  $K$  have very rugged landscapes with a random arrangement of sharp peaks scattered randomly. Networks with low values of  $K$  have smooth landscapes with few peaks. For intermediate values of  $K$ , there are a moderate number of peaks, and they tend to be clustered together rather than scattered randomly across the landscape. Let us define "fitness" for a career system as the overall fit between people and work roles within the career system. For example, a career system which currently has a well-organized set of work roles filled with people who are well suited to their tasks and relate well to their colleagues, is in a high-fitness state. Since very low values of  $K$  are associated with fitness landscapes with very few peaks, there are very few directions in which low- $K$  systems can evolve to improve their overall fitness, and a very limited number of ideal states. The  $K = 1$  career system, then, may be a slow-changing, ponderous beast which is vulnerable to ecological change. So because low  $K$  fitness landscapes have few peaks, there are few choices to be made for improving the fitness of the system, reinforcing pressures to isomorphism and its attendant risks of sectoral vulnerability to environmental change.

Networks with high  $K$  have very rugged fitness landscapes (Kauffman, 1995): they have a great many, randomly-arranged, peaks. A change in the system initiated by a vacancy in a high- $K$  career system could, virtually at random, improve overall system fitness or make it worse. It is rather like walking blindfold across a landscape littered with peaks and chasms: the outcome of every step could be catastrophic, and even if it leads higher, the system can easily become trapped in a sub-optimal state because there are so many randomly-scattered peaks like this one.

NK landscapes with low (but greater than 1) values of K have a smaller number of peaks clustered comparatively closely together (as opposed to chaotic landscapes which have a very large number of peaks scattered all over the landscape), which confers a particular advantage on the system. There are a reasonable number of peaks so that it is possible for a system to evolve to more than one destination, so avoiding becoming trapped in an evolutionary dead end. But because the peaks are clustered, it is easier for the system to improve on its situation by moving from a low peak to a higher one.