

Moving Far From Far-From-Equilibrium: Opportunity Tension as the Driver of Emergence

Abstract:

Complexity scholars have identified two distinct drivers of emergence: (1) Far-from-equilibrium dynamics that trigger order creation, and (2) adaptive tension (McKelvey, 2004) which can push a system toward instability, leading to the emergence of new order. In this paper I suggest that both are true but incomplete. For example, when drawn out to the extreme, a far-from-equilibrium framework generates a contradiction by suggesting that the most dynamic organizations are the ones farthest-from-thermodynamic equilibrium – like Exxon or GE for example. Adaptive tension portrays the *effect* of a dynamic push without identifying the cause. I suggest “Opportunity Tension” as an alternative, which captures the entrepreneurial passion inherent in the drive for order creation and emergence. Opportunity Tension occurs in “pulses,” each cycle leading to a new dynamic state of the system. At a broader level, this model is captured by the notion of “dynamic disequilibrium” (Chiles et al., in press), a construct that indeed moves us far from the issues raised in far-from-equilibrium approaches.

In our search for the driver of order creation, management scholars have developed two contrasting causes of emergent order: far-from-equilibrium dynamics (e.g. Meyer, Gaba, & Colwell, 2005), and adaptive tension (e.g. McKelvey, 2004). Although on the surface these two approaches seem similar, technically the constructs are different in significant ways, which have important implications for an organization science of complexity.

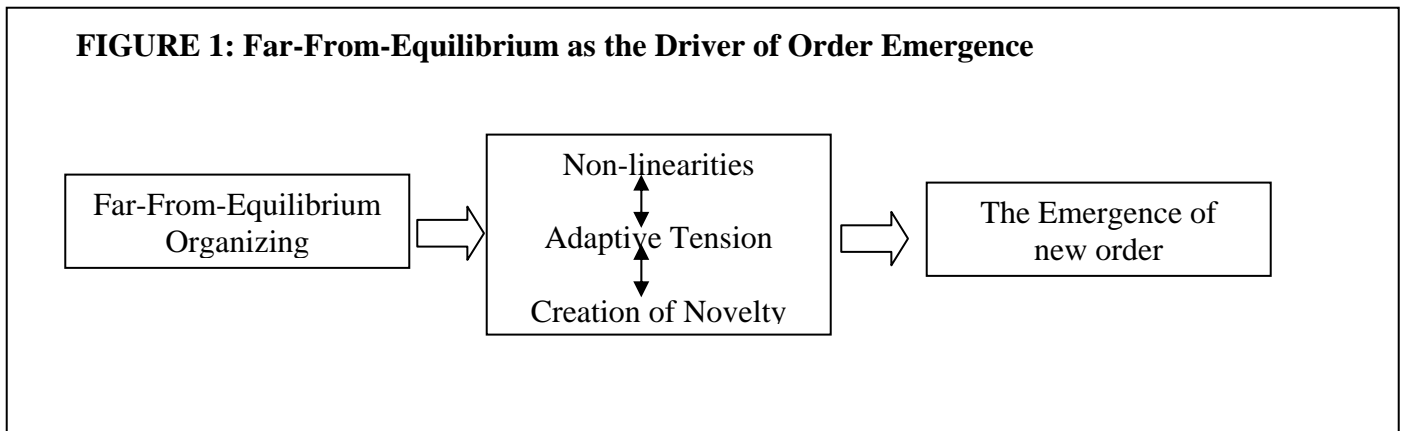
The more common approach for describing the origin of new order is through the onset of “far-from-equilibrium” dynamics. Far-from-equilibrium approaches “elucidate the non-linear mechanisms that actually drive [discontinuous] change forward” (Meyer et al., 2005: 470a). In this theoretical framework, organizing far-from-equilibrium is what leads to “...emergence and ongoing, perpetual novelty” (Meyer et al., 2005: 450b). Dooley and his colleagues (Choi, Dooley & Rungtusanatham, 2001: 356) also use this framework to explain the origin of systemic state change, arguing that such change is triggered “...when the system is far from equilibrium.” Similarly, Chiles and his colleagues (Chiles, Tuggle, McMullen, Bierman & Greening, in press, pg. 2) “...propose that far-from-equilibrium entrepreneurial market processes create...market order.” In sum, a broad range of authors focus on the centrality of far-from-equilibrium processes in order creation and emergence.

On the other hand, McKelvey has offered a different explanation for the driver of emergence, namely *adaptive tension*. In McKelvey’s understanding of Prigogine’s dissipative structures theory (Nicolis & Prigogine, 1989), order creation is caused by and initiated through “energy differentials” which are imposed onto the system. New order is created when one of these energy differentials crosses a threshold (McKelvey 2004: 319): “...[when] an imposing energy differential, what I term *adaptive tension*, exceeds...the lower bound of the region of emergent complexity.” Plowman and her colleagues build on McKelvey’s formulation,

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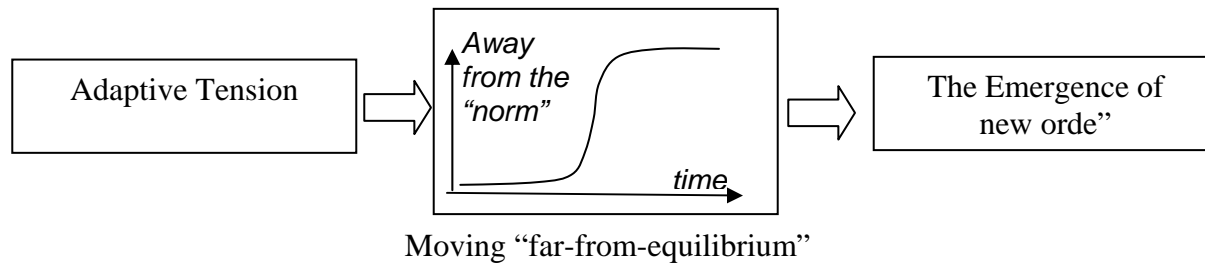
suggesting that periods of organizational instability are often “...full of adaptive tension and tension gradients; it is in this state that emergent self-organization and creative destruction occur” (Plowman, Baker, Beck, Kulkani, Solansky & Travis, 2007: 520). In these models, adaptive tension is the push, the catalyst, the driver that initiates a dynamic state that leads to emergence and order creation.

In sum, we have a bit of a conflict around causality: What actually *causes* the emergence of new order? In the far-from-equilibrium approach, the entire system moves into a regime that is away from equilibrium; this “far-from-equilibrium” organizing leads to non-linearities, adaptive tensions, and ultimately to perturbations of novelty. Under continuing far-from-equilibrium conditions, new order will emerge. This is represented in Figure 1:



In contrast, Adaptive Tension models suggests a nearly opposite ordering. In this view, the onset and increase of adaptive tension will push the system far away from its equilibrium-norm. At a threshold this push will increase non-linearities and other qualities, leading to a new state of emergent order: Presumably, once the new order has emerged, the system returns to a stable functioning, lessening the degree to which it is far-from-equilibrium. This process is represented in Figure 2:

FIGURE 2: Adaptive Tension as the Driver of Order Emergence



On the surface one could say that that this apparent conflict is not a real problem, only an issue of semantics. Furthermore, *both* of these constructs can be traced to the original applications of dissipative structures theory into management, sociology, and social evolution, starting with Jantsch (1980) and including important edited summaries by Ulrich & Probst (1984) and Weber, Depew, & Smith (1990). Further, according to one study (Lichtenstein & Plowman, 2007) these two constructs mean essentially the same thing. So, in what ways is this a conflict, and how is that a problem?

The Far-From-Equilibrium View of Organization

What is Life – A Thermodynamic Explanation

In order to draw out the importance of this distinction between far-from-equilibrium and adaptive tension, it is useful to explore the original application of dissipative structures thinking to biology and management. This synthesis was achieved already in 1944, in Erwin Schrodinger's remarkable book, *What is Life?* Schrodinger made his significant contributions to quantum mechanics in the 1920s and 1930s; in this classic essay he presents a matured and integrated theory

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about how the biological world actually operates, from the bottom all the way up. Essentially his task is to explain how atoms literally (evolutionarily) organize themselves into human beings, and thus to present a thermodynamic explanation for the way that all living matter – from cells to organisms – emerge and are maintained through the importation of “negative entropy.” After a series of chapters dealing with physics and chemistry, he finally reaches the level of an organism. There he finally arrives at his goal: an explanation for how order gets maintained in larger organisms (Schrodinger, 1944: 73):

Thus the device by which an organism maintains itself stationary at a fairly high level of orderliness (= fairly low level of entropy) really consists in continually sucking orderliness from its environment.

What does it mean to “suck orderliness” from its environment? Essentially he’s suggesting that “order” is a compact form of energy; in order for an organism to maintain itself, it needs to import high degrees of energy into itself. This insight became the core of open systems thinking (Katz & Kahn, 1966; Thompson, 1968) autopoiesis and similar models (Maturana & Varela, 1980; Csanyi & Panzer, 1985; Swenson, 1992; Drazin & Sandelands, 1992), and provides the theoretical fulcrum for Prigogine’s theory of dissipative structures. However, Schrodinger is not done. He concludes by asking, what is the “form of orderliness” that gets sucked in to maintain organisms in their dynamic equilibrium?

...Indeed, in the case of higher animals we know the kind of orderliness they feed upon well enough, viz. the extremely well-ordered state of matter...which serve them as foodstuffs. [P]lants...of course, have their most powerful supply of negative entropy in the sunlight. (Schrodinger 1944: 74)

In effect, the more ordered an entity becomes, the farther away from statistical equilibrium it operates, and the more “negative entropy” it needs to import in order to remain in “dynamic

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equilibrium” with its environment. McKelvey used this formulation even from his first articles on complexity (e.g. Maguire & McKelvey, 1999: 29):

The key question becomes: What keeps emergent structures in states of equilibrium far above entropy, that is, in states that violate, locally, the 2nd law? Prigogine & Stengers (1984) observe that energy importing, self-organizing, open systems create structures that in the first instance increase neg-entropy...[These structures] are labeled “dissipative structures,” because they are the sites where imported energy is dissipated.

The more entropy dissipated, the more order is created, through a web of nested and coevolving ecologies (Weber, 1990). As further levels of order are created, the system as a whole moves farther and farther away from equilibrium. Right? Or does it?

Far-, Farther-, and Farthest-Away-From-Equilibrium

To draw out the metaphor in economic terms, consider the following: An entrepreneurial firm is an “energy conversation system” (Slevin & Covin, 1997) of inputs, transformations, and outputs (Scott, 1981). In entrepreneurial terms, these inputs are essentially its cash flows and other resources; internal transformations are the business functions or entrepreneurial activities which produce value for customers (Afuah, 2004), and the outputs are the goods or services being offered by the firm. In exchange for the value they receive through these goods or services, customers purchase these offerings using money – an “extremely well-ordered state of matter” as Schrodinger would say. As such, entrepreneurial firms “convert” potential pools of resources – a potential market – into revenue that sustains the firm, by creating products or services which serve this market (Shane & Venkataraman, 2000). Accordingly, the more (net) operating revenue being imported into a firm, the farther-away-from-equilibrium the firm will be.

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Again, in formal terms this way of thinking is easy to visualize. Consider a small entrepreneurial businesses, e.g. the classic mom and pop grocery store, or a sole proprietorship. These companies represent a simple business model design (Zott & Amit, 2007) in which the net revenues from sales (i.e. operating revenues with Cost of Goods Sold subtracted) are sufficient to pay for Fixed Costs (including employee salaries and managers draw or founder's take-home salary). "Lifestyle ventures" like these are organized primarily to create a stable lifestyle for the lead entrepreneur(s) and those they employ. Although small, firms like these are in far-from-equilibrium conditions, as you know if you've ever founded or worked in a company like this! And note that firms of 20 or fewer employees make up more than 90% of total number of businesses in the U.S. economy (Aldrich, 1999)

Pushing the metaphor further, some ventures identify larger pools of potential resources – i.e. by identifying larger markets (Bhide, 2000) – and find new ways to serve them by creating and accessing the resources necessary to capitalize on those markets (Gartner, 1985; Stevenson & Gumpert, 1985). If we simply define the "distance from equilibrium" of a firm as its overall cash flows or net operating revenues (perhaps combined as an index) then the more revenues in a firm, the farther-away-from-equilibrium the firm would be operating. This reasoning makes sense in thermodynamic terms; for example, Whole Foods Inc. is operating much farther-from-equilibrium than our local independent health food store, and both of these are dwarfed by regional supermarkets like Shaws or national chains like Kroeger.

But we are getting into a problem here – a problem that complexity scholars have not well grappled with. By this reasoning, the farthest-from-equilibrium firms in the world – measured by net revenues – would be Walmart, GM and Exxon/Mobile – the latter earned \$40.6 Billion dollars in net profit in 2007, with more than \$400,000,000,000 in revenues. But, this

result is not quite what we have in mind when we describe organizations in far-from-equilibrium conditions, nor would complexity scholars point to Exxon or WalMart as exemplars of self-organizing! Instead, Exxon and GM seem to exemplify the opposite: Firms that abide by a model of General Linear Reality (Abbott, 1988), with managers who lead by control, under the assumption of *independent* agents who operate according to Gaussian averages (McKelvey & Andirani, 2005). The recent “Great Recession” has shown, if nothing else, the inaccuracy of all of these assumptions. So, if not far-from-equilibrium, what then drives order creation?

“Opportunity Tension” as the Driver of Emergent Order

As an alternative, consider the notion of “Opportunity Tension.” This concept draws from McKelvey’s (2004) term, adaptive tension: a dynamic, teleological drive to access energy potentials. In a similar way, Opportunity Tension represents an internal drive, the entrepreneur’s intention, which arises with his/her perception and co-creation of a business opportunity (Alvarez & Barney, 2007). Opportunity Tension is initiated when an entrepreneur identifies and begins to develop a business opportunity, i.e. an energy differential which defines a (niche) market, and simultaneously constructs a way to capitalize on that economic potential through a unique and sustainable business model (Zott & Amit, 2007).

Once identified, enacting an opportunity takes a huge amount of time, commitment and effort – a great deal of intention and action. Empirical evidence shows that the greater this drive to action the more likely that a business will actually emerge as an independent start-up venture (Lichtenstein, Carter, Dooley, & Gartner, 2007). Thus, Opportunity Tension is generated through great personal passion (Adler & Obstfeld, 2007) – a “creative tension” within the entrepreneur (Fritz, 1984; Senge, 1990) that leads to capitalizing on the opportunity. As McKelvey confirms,

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this tension is sparked by an economic “energy differential” – a potential market of resources, *and* by a motivation to act: “Energy differentials need to have a motivational valence attached before they can be expected to be felt as tension by agents” (McKelvey, 2001: 195). This motivational valence is Opportunity Tension: it’s the felt belief that the opportunity is viable and worth pursuing. This internal Opportunity Tension effectively pushes an entrepreneur to organize a business. More broadly, Opportunity Tension is the key driver of entrepreneurial order-creation.

But this urgency, this push, does not last forever. The internal tension that drives action does exist indefinitely, nor is it “stabilizing.” Like the source of creative tension in artists (Fritz, 1989), adaptive tension motivates and drives action for an intense period of time, sometimes generating a kind of “flow” state (Csikszentmihalyi, 1990). Within this flow state organizing continues until the initial goal is achieved (Lichtenstein, et al., 2007), or the goal itself may shift through the organizing process (Lichtenstein, Dooley, & Lumpkin, 2006, Sarasvathy, 2001). Opportunity Tension is thus a *pulse of activity* – a committed intention to put oneself “in-tension” by pursuing this project and generating an emergent result. If everything works – and see the entire entrepreneurship literature for our understanding what that means – a new business will emerge: New order will come into being that literally converts the market potential into real value to be received by a target market; they pay for that value using new resources that keep the organizational operating.

In the best of these self-organizing ventures, the firms themselves are often organized as highly innovative “novelty-centered” businesses (Zott & Amit, 2007) that incentivize all employees to support and produce an ongoing stream of adaptive tensions. An increasing amount of research is describing the results of this generative approach to organizing, starting

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with Brown & Eisenhardt's (1997) analysis of "self-organizing in project groups," and now including Garud and his colleagues' examination of emerging structures and institutions (Garud, Jain, & Kumaraswamy, 2002; Garud, Kumaraswamy, & Sambamurthy, 2006), Feldman's (2000) exposition on routines for change, Rindova & Kotha's (2001) description of "continuous morphing" and so on. In this view Zott & Amit's (2007) insightful construct of "novelty-centered businesses" supports the idea that "far-from-equilibrium" conditions represent a culture or business model of high-energy, innovation-based organizing. This state is highly dynamic, and yet it can generate and regenerate itself for long periods of time, i.e. it is a dynamic state that appears to be relatively "stable."

A Difference that Makes a Difference

As I mentioned above the "far-from-equilibrium" approach can unwittingly lead to describing organizations that are anything but innovative – with GM as formative example. And yet, the notion of far-from-equilibrium organizing is meaningful and important, as Meyer and his colleagues (2005) have shown. A similar view is here from Plowman et al., (2007: 520a):

When organizations...are pushed to a state far from equilibrium...they can display highly complex behavior; that is, they are orderly enough to be stable but also full of surprises, and contradictory forces operate simultaneously, pulling the organization in different directions. ...[T]hese counteracting forces may push the organization away from equilibrium into a more chaotic state...

According to this analysis, far-from-equilibrium means pushed far away from the non-creative, bureaucratic norm of mid-20th century organizations, into a space of increased differences (Goldstein, 1986) leading to higher innovation, creativity, and learning (Nonaka, 1988). Once an organization moves into this state, member activities will instantiate and support it until this far-from-equilibrium condition is itself rather stable or "normal" for the company.

But initiating that state is certainly not normal. Only a unique or unusual event (Andriani & McKelvey, 2007) would have the power to get beyond organizational inertia, the power to start a process of novel organizing and emergent order creation. McKelvey (2001) shows this in his exemplar of adaptive tension: Jack Welch, as the CEO of GE, catalyzed adaptive tension in every business there by giving them only *one* success metric: “Be #1 or #2 in your industry, or be reorganized, split up, or sold.” This charge is not an “average” or “normal” event – it is extreme, perhaps one of the most extreme challenges ever given to a set of firms. And, the result – conditioned by Welch’s remarkable leadership – was also extreme, as GE became one of the most financially successful corporations in the past 100 years.

In my formulation, this kind of extreme event is driven by Opportunity Tension: Welch as entrepreneur recognizes that the tension caused by raising the bar is strong enough to spark a new kind of thinking – an entrepreneurial, opportunity-driven mindset – through which these executive managers can identify and act on formative new business opportunities. In the same way, distinctive events can be the origin of order creation. It is in rare moments of extreme tension that an individual sees an opportunity for change, and at the same time feels the internal drive to act on that opportunity. Such experiences, along with the commitment and follow-up they catalyze, are rare, unique, memorable, and powerful.

In summary: Far-From-Equilibrium is a *state* – an ongoing, systemic condition that has been shown to increase innovativeness and performance (e.g. Nonaka, 1988; Smith & Comer, 1994). Opportunity Tension, in contrast, is a *drive* – an intensive push to capitalize on a time-sensitive opportunity, which is internally motivated by a felt urgency to take action *now*. Opportunity Tension is an internally felt drive that leads to agency and action, in other words, it describes the drives of an agent. Agency is a passion expressed by agents (Adler & Obstfeld,

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2006) – entrepreneurs, effective leaders, cohesive teams, and so on. At the same time, this passion and drive (intention) is based on the perception of a pool of possibility (opportunity), for creating new value for customers who want it. If I feel I can really do this, the opportunity becomes alive – immediately creating a Tension within. When there is opportunity *and* (in)tension, then the organizing process begins. Thus, Opportunity Tension is the driver of new order creation.

Moving Far From Far-From-Equilibrium: Cycles of Opportunity Tension

Taking this to its extreme, we can begin to envision a truly dynamic systems science that is built around disequilibrium processes as the norm (McKelvey, 2006; McKelvey & Andriani, 2005; Meyer et al., 2005). In order to get there, however, we first have to move beyond the “far-from-equilibrium” terminology. For although we may indeed be examining dynamics that are “far-from” an equilibrium state, those far-from-equilibrium dynamics are still being defined *in terms of* “equilibrium.” As Chiles et al. (in press) point out, “...scholars sometimes treat equilibrium as the natural reference point for social systems, even though their central concern is far-from-equilibrium phenomena.” To react against equilibrium in this way means that we position our arguments and measurements as contrary to *equilibrium* (and General Linear Reality – Abbott, 1988). What then is the alternative – how would we language a dynamic systems science that *assumes* interdependence and non-linearity? In the words of Meyer and his colleagues (2005: 471) such an approach would “...embrace notions like co-evolution, CAS, field configuration, network formation, autocatalytic feedback, niche evolution, and emergence.”

As Dooley and others have pointed out, this process of emergence is often expressed as a “state change” within an organization, as the firm or company move from one “dynamic state” to another over time. For example, Plowman and her colleagues show how Mission Church

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transformed from a “silk-stockings” congregation in one era to a social activist community in a new era, working to improve inner-city conditions from the ground up. Chiles and his colleagues show how the emergence of Branson, MO occurred in a series of “epochs,” each one representing a transformative shift from one set of conditions to another set. Lichtenstein, Dooley & Lumpkin’s (2006) exploration of one start-up venture identified an “emergence event” there – a punctuated shift in strategy and vision which totally altered the nature and process of entrepreneurial organizing.

In each of these cases an entrepreneurial leader(s) identified one opportunity, followed by *another new opportunity*; each of these initiated a new cycle of Opportunity Tension. Each of these cycles represents a distinct phase of activity which may well result in another degree of order that yields more novelty in the market, attracting more customers (additional revenue streams) and maintaining the organization at this next dynamic state. As we mentioned above, this pulse of activity is followed by a period of integration, as the new dynamic state finds its own optimal functioning – it’s richest mix of “orderliness” that can be “sucked” from the potential in the marketplace. At the same time, entrepreneurial leaders are always on the lookout for new opportunities – the next one may catapult the organization to yet another new dynamic state.

Opportunity Tension is thus like a periodic attractor, which is experienced as a series of ebbs and flows in the development of an organization. (Kevin Dooley came up with this idea.) High-potential entrepreneurs like Richard Branson or Steve Jobs or Howard Schultz build their firms through successive, powerful rounds of Opportunity Tension. In a broader sense, all organizations may grow through these cycles of Opportunity Tension, each one leading to another dynamic state in the development of the firm (Levie & Lichtenstein, 2008).

A marvelous phrase for this process is “dynamic disequilibrium” – this construct is suggested by Chiles and his colleagues (Chiles et al., in press). Their expectations about this process are important enough to present at some length:

As markets evolve farther from equilibrium, we thus expect to see the pattern of entrepreneurial product offerings and resource combinations continually re-created at bifurcation points. Moreover, the spiraling dynamics of momentum in organizations (Jansen 2004), the increasing momentum of positive feedback processes leading to a single bifurcation (Lichtenstein et al. 2007), and the temporal spacing of multiple bifurcations in markets (Chiles et al. 2004) all lead to an important expectation: Positive feedback processes should progressively increase momentum and decrease the time between bifurcation points. Such market processes match a virtually unknown *punctuated disequilibrium* pattern... (pg. 37).

Thus, each new “dynamic state” is caused (initiated) by an Opportunity Tension – the driver of order creation. Then, once that next level or structure is created, the tension naturally declines until the more expanded system-as-a-whole moves back to a dynamic state of disequilibrium.

Such an order creation process is rare – it is an “extreme event” that pushes the system beyond its norm, outside of its “safety zone,” and into a new level of order (McKelvey & Andriani, 2005). Further such an extreme event is viable *only if* there is a potential pool of resources that the agent is organizing toward. That’s because in order to maintain this new, expanded system, a higher amount of “negative” entropy is needed – that is, the system requires net more resources than before the shift, in order to maintain itself in its new expanded “niche” (Panzar & Csanyi, 1985). Essentially this requires that all (new) organizing generates a benefit of some kind, i.e. it is based on a discoverable opportunity that reveals new resources which can be imported into the system in a sustainable way. Following Schrodinger this evolutionary build-up of order leads to organisms of all kinds. Expanding further, this approach explains the

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growth and development of human social communities (Carniero, 1970, 1987), the growth of cities (Dyke, 1988), and expanding order in society generally (Adams, 1988; Coren, 1998).

In sum, a model of dynamic disequilibrium, driven by cycles of Opportunity Tension, may help explain the production of order at all levels, providing the groundwork for a truly dynamic systems science that takes us far from far-from-equilibrium.

REFERENCES

- Abbott, A. 1988. Transcending general linear reality. *Sociological Theory*, 6: 169-186.
- Adams, R. N. 1988. *The Eighth Day: Social Evolution as the Self-Organization of Energy*. Austin, TX: University of Texas.
- Adler, P., & Obstfeld, D. 2006. The role of affect in creative projects and exploratory search. *Industrial and Corporate Change*, 16: 19-50.
- Afuah, A. 2004. *Business Models: A Strategic Management Approach*. Boston, MA: McGraw Hill Irwin.
- Aldrich, H. (1999). *Organizations Evolving*. Newbury Park, CA, Sage Publications.
- Alvarez, S. and J. Barney (2001). How entrepreneurial firms can benefit from alliances with large partners. *Academy of Management Executive* 15(1): 139-148.
- Bhide, A. 2000. *The Origin and Evolution of New Businesses*. N.Y.: Oxford University Press.
- Brown, S., & Eisenhardt, K. 1997. The art of continuous change: Linking complexity theory and time-based evolution in relentlessly shifting organizations. *Administrative Science Quarterly*, 42: 1-34.
- Carniero, R. 1970. A theory of the origin of the state. *Science*, 169: 733-738.
- Carniero, R. 1987. The evolution of complexity in human societies and its mathematical expression. *International Journal of Comparative Sociology*, 28: 111-128.
- Coren, R. 1998. *The Evolutionary Trajectory: The Growth of Information in the History and Future of the Earth*. Amsterdam: Gordon and Breach Publishers.
- Csanyi, V. and G. Kampis (1985). Autogenesis: Evolution of replicative systems. *Journal of Theoretical Biology* 114: 303-321.
- Csikszentmihalyi, M. 1990. *Flow: The Psychology of Optimal Experience*. NY: Harper & Row.
- Drazin, R. and L. Sandelands (1992). Autogenesis: A perspective on the process of organizing. *Organization Science* 3: 230-249.
- Dyke, C. 1988. Cities as dissipative structures. In B. Weber, D. Depew, & J. Smith (Eds.), *Entropy, Information and Evolution: New perspectives on physical and biological evolution*. Cambridge, MA: M.I.T. Press.
- Feldman, M. 2000. Organizational routines as a source of continuous change. *Organization Science*, 11: 611-629.

- Fritz, R. 1989. **The Path of Least Resistance**. New York, NY: Fawcett Columbine.
- Garud, R., Jain, S., & Kumaraswamy, A. 2002. Institutional entrepreneurship in the sponsorship of common technological standards: The case of Sun Microsystems and Java. ***Academy of Management Journal***, 45(196-214).
- Garud, R., Kumaraswamy, A., & Sambamurthy, V. 2006. Emergent by design: Performance and transformation at Infosys Technologies. ***Organization Science***, 17: 277-286.
- Goldstein, J. 1986. A far-from-equilibrium systems approach to resistance to change. **Organizational Dynamics**, 15(1): 5-20.
- Jantsch, E. 1980. **The Self-Organizing Universe**. New York, NY: Pergamon Press.
- Katz, D. and R. Kahn (1966). ***The Social Psychology of Organizations***. New York, NY, Wiley.
- Lichtenstein, B., Carter, N., Dooley, K., & Gartner, W. 2007. Complexity dynamics of nascent entrepreneurship. ***Journal of Business Venturing***, 22: 236-261.
- Lichtenstein, B., Dooley, K., & Lumpkin, T. 2006. Measuring emergence in the dynamics of new venture creation. ***Journal of Business Venturing***, 21: 153-175.
- Maturana, H. and F. Varela, (1980). ***Autopoiesis and Cognition***. Dordrecht, Holland, D. Reidel Publishing.
- McKelvey, B. 2001. What is complexity science? It is really order creation science. ***Emergence***, 3(1): 137-157.
- McKelvey, B. 2004. Toward a 0th Law of Thermodynamics: Order creation complexity dynamics from physics and biology to bioeconomics. ***Bioeconomics***, 6: 65-96.
- McKelvey, B. 2006. Van de Ven & Johnson's "Engaged Scholarship": Nice try, but... ***Academy of Management Review***, 31: 822-829.
- McKelvey, B., & Andriani, P. 2005. Why Gaussian statistics are mostly wrong for strategic organization. ***Strategic Organization***, 3: 219-228.
- Meyer, A., Gaba, V., & Colwell, K. 2005. Organizing far from equilibrium: Nonlinear change in organizational fields. ***Organization Science***, 16(456-473).
- Nicolis, G., & Prigogine, I. 1989. **Exploring Complexity**. New York, NY: W. H. Freeman.
- Nonaka, I. 1988. Creating organizational order out of chaos: Self-renewal in Japanese firms. **California Management Review**, Spring: 57-73.
- Plowman, D. A., Baker, L., Beck, T., Kulkarni, M., Solankysy, S., & Travis, D. 2007. Radical Change Accidentally: The Emergence and Amplification of Small Change. ***Academy of Management Journal***, 50: 515-543.

- Prigogine, I., & Glansdorff, P. 1971. *Thermodynamic Theory of Structure, Stability, and Fluctuations*. New York: Wiley & Sons.
- Rindova, V., & Kotha, S. 2001. Continuous "morphing": Competing through dynamic capabilities, form, and function. *Academy of Management Journal*, 44: 1263-1280.
- Sarasvathy, S. 2001. Causation and Effectuation: Toward a theoretical shift from economic inevitability to entrepreneurial contingency. *Academy of Management Review*, 26: 243-263.
- Schrödinger, E. 1944. *What is Life?*: Cambridge University Press.
- Scott, R. 1981. *Organizations: Rational, Natural, and Open Systems*. N.J.: Prentice-Hall.
- Shane, S., & Venkataraman, S. 2000. The promise of entrepreneurship as a field of research. *Academy of Management Review*, 25: 217-226.
- Slevin, D. and J. Covin (1997). Time, growth, complexity, and transitions: Entrepreneurial challenges for the future. *Entrepreneurship Theory and Practice* 22(2 (Winter)): 53-68.
- Smith, C., & Comer, D. 1994. Change in the small group: A dissipative structure perspective. *Human Relations*, 47: 553-581.
- Stevenson, H., & Gumpert, D. 1985. The heart of entrepreneurship. *Harvard Business Review*, 63(2 (Mar/Apr)): 85-94.
- Swenson, R. (1992). Autocatakinetics, yes - Autopoiesis, no: Steps toward a unified theory of evolutionary ordering. *International Journal of General Systems* 21: 207-228.
- Thompson, J. (1967). *Organizations in Action*. N.Y., McGraw Hill
- Ulrich, H., & Probst, J. B. (Eds.). 1984. *Self-Organization and Management of Social Systems*. Berlin: Springer-Verlag.
- Venkataraman, S. 1996. *Some methodological challenges for entrepreneurial process research*. Paper presented at the National Academy of Management Meeting, Cincinnati, OH.
- Weber, B. H., Depew, D. J., & Smith, J. D. (Eds.). 1990. *Entropy, Information, and Evolution*. Cambridge, MA: MIT Press.
- Zott, C., & Amit, R. 2007. Business model design and the performance of entrepreneurial firms. *Organization Science*, 18((2)): 181-199.