

Generative leadership: Nurturing innovation in complex systems

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This paper contributes a theoretical framework for generative leadership, a form of leadership that creates a context to stimulate innovation in complex systems. Our framework links theories of leadership with perspectives on innovation and complex systems to suggest that generative leadership involves balancing connectivity and interaction among individuals and groups in complex systems by managing complexity and institutionalizing innovation. By focusing on how generative leaders create conditions that nurture innovation rather than individual traits or creativity, our framework provides new directions for leadership research and policy implications for managers.

Introduction

"If man is not to do more harm than good in his efforts to improve the social order, he will have to learn that in this, as in all other fields where essential complexity of an organized kind prevails, he cannot acquire the full knowledge which would make mastery of the events possible" (Friedrich August von Hayek).

It is clear from the pervasive impact of distant events, both natural and man made, that we inhabit a complex and interdependent world. Havoc wreaked by disasters such as floods in New Orleans, tsunamis in Southern Asia, the spread of bird flu, oil shocks, or stock market crashes have far-reaching effects. The impact of good fortune is also widespread, as exemplified by stock market and real estate booms and productivity gains from using internet and other new technologies. Action is local, yet likely to have global effects. Firms, organizations, and nations are not isolated, but, rather, interdependent parts of a complex system. Moreover, a complex systems world view highlights that *interactions* between parts of the system and the behavior of the system as a *whole* are critical. Yet how interactions are managed by agents to influence the behavior of the whole system is not well understood.

Research from a complexity perspective

suggests that organizations are complex systems composed of interacting agents that learn, adapt, and co-evolve. Moreover, fostering innovation to facilitate adaptation to a changing environment necessitates understanding the dynamics and evolution of complexity in natural systems (Levinthal, 1997). While this view has largely been applied to the design of complex systems, (Levinthal and Warglien, 1999; Rivkin, 2001; Siggelkow and Rivkin, 2005), the critical issue of *how* leadership can be exercised to nurture innovation, adaptation, and high performance over time is insufficiently emphasized. Hence, we investigate the following research question in this paper: "How can leadership be exercised in a complex, interdependent world to foster problem solving and innovation?"

We contribute new insights by linking research on complexity and leadership to develop a framework for *generative leadership*, defined as those aspects of leadership that foster innovation, organizational adaptation, and high performance over time. A critical element of generative leadership is the ability to seek out, foster, and sustain generative relationships (Lane and Maxfield, 1996) that yield new learning relevant for innovation. This, in turn, requires a nuanced understanding of the environment and an ability to structure situations and manage interactions. Although other aspects of leadership may also be important to system sustainability, they are not the subject of this analysis. Here we focus on the role of generative leadership as a catalyst for innovative adaptation from a theoretical perspective and as applied to a case study of an Indian automotive manufacturer.

Theoretical background

Leadership research

Earlier perspectives on leadership focus largely on individual traits and behaviors to elicit super-ordinate performance, whether via transactional, instrumental (House, 1971; Luthans and Kreitner, 1975; Podsakoff *et al.*, 1982), charismatic, transformational (Shamir *et al.*, 1993; Burns, 1978; Bass, 1985; Bennis and Nanus, 1985;

Kouzes and Posner, 1987; Judge and Piccolo, 2004), or value-based approaches (House and Aditya, 1997; Conger and Kanungo, 1987; Shamir *et al.*, 1993). While team-oriented leadership theories like leader-member exchange theory (Graen and Cashman, 1975; Graen *et al.*, 1982; Wakabayashi and Graen, 1984; Graen and Uhl-Bien, 1995) highlight the importance of role-based exchanges between leaders and team members, they do not emphasize how a rapidly changing context alters roles dynamically. In contrast, entrepreneurial leadership (Gupta *et al.*, 2004) emphasizes innovation and problem solving and notes that context is an important element of leadership.

Yet, previous perspectives focus on leaders' individual characteristics rather than on the dynamics of interactions between leaders, group members, and the context in complex organizational systems over time; nor do they sufficiently elucidate how leaders create conditions that allow their organizations to evolve.

Innovation research

It has been shown that innovation in organizations may stem from technical or administrative systems (Damanpour, 1991), and may be incremental or radical (Henderson and Clark, 1990; Kuhn, 1970). Research suggests that promoting innovation necessitates:

- A diversity of experience, expertise, and affect to allow pooling of relevant knowledge from various sources (Ancona and Caldwell, 1992; Dougherty and Hardy, 1996; Cohen and Levinthal, 1990);
- Repeated practice (Pisano, 2000) or cognitive search (Gavetti and Levinthal, 2000);
- Champions that insulate the group from everyday pressures, and provide resources to permit sustained and focused activity on specific projects (Shane *et al.*, 1995; Dougherty and Hardy, 1996; Leonard-Barton, 1995);
- Presenting a challenge on which organizational survival depends (Dougherty and Hardy, 1996);
- Exploiting innovations through rapid market testing to gain feedback, make modifications, and determine whether to continue pursuing specific innovation trajectories (Clark and Fujimoto, 1991; March, 1991).

Studies have examined innovation in the context of technology adoption (Van de Ven, 1986; Van de Ven *et al.*, 1989; Rogers, 1983), culture (Shane *et al.*, 1995), creativity (Amabile *et al.*, 1996), learning, capability building, exploration and exploitation (Winter and Szulanski, 2001; March, 1991), performance (Lawless and Anderson, 1996), sources of innovation (Wade, 1996; von Hippel, 1988), and characteristics of innovation adopters (Greve *et al.*, 1995). However, few studies link innovation with leadership and complex systems.

Complex adaptive systems

We consider complex adaptive systems here since they are suitable for modeling problems in a variety of domains, including leadership (Carley and Prietula, 1994; Anderson, 1999; Hazy, in press; Marion and Uhl-Bien, 2001), to yield insights into the dynamics of evolution (Arthur, 1997, 1999; Hage, 1999; Simon 1965). In general, models of complex adaptive systems (CASs) highlight the relational aspect of complexity. Four elements of CASs are relevant for organizational theorists:

- First, outcomes emerge from actions of agents at a lower level of aggregation (Holland and Miller, 1991);
- Second, self-organization in the system is emergent as a result of the interdependent behavior of agents who act on local information (Anderson, 1999). These interactions need to remain within a delicate range to prevent stagnation and decay on the one hand, and unpredictable, random dynamics on the other (Kaufmann, 1993; Carroll and Burton, 2000);
- Third, since agents co-evolve with one another (Holland and Miller, 1991; Levinthal, 1997), the processes and structures that emerge from their interactions are dynamic and not static (Anderson, 1999);
- Fourth, complex adaptive systems evolve over time through the entry, exit, and transformation of agents. Continuous evolution ensures that CASs operate far from the equilibrium of what may otherwise be thought of as globally optimal system performance (Holland and Miller, 1991; Kauffman, 1995). Nevertheless, this sub-optimality is not necessarily disadvantageous.

Studies using Kauffman's NK adaptive landscape model (McKelvey, 1999; Rivkin, 2000; Levinthal, 1997; Siggelkow and Rivkin, 2005; Carroll and Burton, 2000; Levinthal and Warglien, 1999; Brown and Eisenhardt, 1997), cellular automata models (Lomi and Larsen, 1997), neural networks (Heydebrand, 1989), and genetic algorithms (Bruderer and Singh, 1996) suggest that for any level of differentiation, moderate levels of integration will outperform low or high levels of integration. However, with some notable exceptions (Hazy, 2004), computational models do not apply a complexity perspective to leadership and innovation. Similarly, despite noting cognitive and behavioral complexity (Weick, 1979; Denison *et al.*, 1995), with only a few exceptions (Marion and Uhl-Bien, 2001), leadership research does not emphasize interactions in complex systems. Hence, in the following section we apply a complexity science approach and present a framework for generative leadership that stimulates innovation in complex organizations.

A framework for fostering innovation via generative leadership

For adaptation to occur, effective leadership creates a system in which appropriate collections of knowledgeable individuals can be brought together and allowed to interact with minimal friction and under conditions that catalyze innovation. Since such interactions generate new understanding, knowledge, and meaning, an important element of generative leadership is the ability to seek out, foster, and sustain generative relationships (Lane and Maxfield, 1996). Generative leadership is particularly relevant in situations of complexity when uncertainty and rapid change are dominant; since outcomes are not certain, the focus must be on the process. In a complexity science context, this type of leadership, or any leadership for that matter, must be implemented in the context of how it affects the simple, local rules that govern agent-to-agent interactions.

Our model of generative leadership uses a complexity science perspective to yield fresh insights on dynamic processes underlying innovation and departs somewhat from prior research, in that it suggests that it is not simply the composition of the team or the ability to increase interactions but *how* interactions are managed and regulated that

leads to innovation. It focuses on the management of complexity itself as an enabler of innovation and explores the role of leadership as the catalyst that creates an effective context for innovation to occur. It emphasizes ways in which complexity can be reduced and absorbed structurally in the system without limiting the richness of interaction that is critical to innovation.

Thus, our generative leadership model explores what steps can be taken to manage interactions even in highly complex environments to help focus and direct the team's attention. For example, attention can be focused by partitioning tasks to allow effort to be concentrated and structured within a confined, often specialized context, rather than allowing attention to be continually distracted in unstructured interactions that, because of their diffuse nature, do not allow for the accumulation of knowledge and capabilities. Moreover, generative leaders promote information flow and feedback seeking. A consequence is that exploitation and exploration can be managed concurrently (March, 1991). Similarly, exercising generative leadership involves problem solving and innovation and suggests that these can be distributed on a wider scale rather than limited to a few organization members at the top of the hierarchy or within a specialized group. It also suggests that innovation can be institutionalized and that novelty and system evolution are generated from simple rules that operate locally. While rules are necessary for all innovation processes at various stages, in this paper we focus specifically on rules for interaction to aid problem solving and innovation. Table 1 situates generative leadership in the context of other studies on leadership.

Facilitating innovation via generative leadership

Successful innovations link a genuine purpose or need with an effect that can be exploited to satisfy it. The ability to solve problems collaboratively is thus critical, since innovations often result from the recombination of existing and unfamiliar technologies and knowledge from diverse sources (Fleming, 2001; Cohen and Levinthal, 1990). Systems evolve to handle more complexity over time by matching internally generated variations with the variety of the environments they encounter, thus enhancing their survival chances and improving repro-

Perspective on leadership	Characterization of environment	Characterization of innovation
Charismatic/transformational leadership	Effective in situations of ambiguity; environment not emphasized.	Catalyzes organizational change through leader's ability to elicit extraordinary effort from followers. Primary focus on individual leader characteristics. Innovation not emphasized.
Value-based/team-oriented leadership	Effective in stable environments; environment not emphasized.	Organizational change through leader-member exchange. Focus on values and leader-member exchange in teams. Innovation not emphasized.
Entrepreneurial leadership (Gupta <i>et al.</i> , 2004)	Effective in turbulent environments.	Helping to bring innovation to market by ensuring adherence to vision, emphasizing problem solving, and providing resources. Focus on characteristics of individual entrepreneur/leader necessary to elicit creativity, problem solving, effort, and achievement of aspirations and goals.
Generative leadership, based on complexity theory, complex adaptive systems (Surie and Hazy, 2006); other research from complex systems perspective (Thompson, 1967, Lawrence and Lorsch, 1969; Damanpour, 1991; Kauffman, 1993; Anderson, 1999; Hage, 1999; Brown and Eisenhardt, 1997; Siggelkow and Rivkin, 2005; Levinthal, 1997; Levinthal and Warglien, 1999)	Effectiveness contingent on match between system design and environment. Environment is a key factor in overall system performance.	Change and innovation necessitate manipulating organization design and interactions within and between sub-systems as well as between different systems. Innovation may be technical or organizational. Focus on organization as a complex system of interacting elements including individual agents, groups, and organizations. Leadership involves tuning the system for innovation, growth, and high performance via manipulation of interactions. Innovation involves changing the system-environment <i>model</i> .

Table 1 *Linking leadership, innovation, and complexity*

ductive fitness (Boisot and Child, 1999; Ashby, 1954). Survival and evolution, in turn, are predicated on the ability to solve problems and innovate.

We view innovation as a social process rather than a purely technical one; innovation emerges in the context of interactions to solve problems (Wenger, 1998). Therefore, we posit that generative leadership can catalyze innovation by structuring the overall context in which agents operate to sustain positive and powerful interactions while managing complexity. Various types of agents include individuals, organizational sub-units, the organization as a whole, and the community in which organizations co-evolve. Generative leadership focuses on managing interactions within

the entire organizational ecology by institutionalizing rules for collaboration.

Successful innovation teams require clear, stable rules and objectives to regulate action, while collaborative efforts yielding innovation require learning how to interact effectively (Lynn and Reilly, 2002). However, as more information is gathered about the need in the environment and the system's set of potential approaches to exploit it, a complex system such as this carries the risk that its own complexity can overwhelm it (Anderson, 1999). Hence, internal interactions must be regulated to prevent a "complexity catastrophe" – the break point where the interdependence between actors (or elements of the system) overwhelms the system's ability to

digest all that interaction (Kauffman, 1993). Thus, while bringing together the right combination of interactions to create innovation, generative leadership must also limit the number of interactions so that each individual's ability to perceive, interpret, and synthesize knowledge is challenged but not overloaded.

Boisot and Child (1999) note that complexity can be managed either through complexity reduction or complexity absorption. Complexity reduction involves using routines and standards to articulate and codify knowledge, while complexity absorption involves building relationships to gain access to information available to those perceived as clan members. In the next two sections we outline five processes that generative leaders follow to regulate complexity while enhancing interactions, and three processes that help to institutionalize innovation.

Regulating complexity

Generative leadership induces a continued focus on problem solving and innovation by facilitating interactions while regulating complexity. As shown in Figure 1 later, this necessitates managing the *context for innovation* to structure various aspects of interactions in support of evolutionary processes. Consequently, generative leaders focus on processes that influence the following five aspects of interactions.

Interaction experience

Since innovation occurs largely within one-to-one interactions, one idea building on another in untested variations, fostering system-wide innovation necessitates regulating interactions to ensure that all or most interactions are *experienced* by participants as dyadic even if they are one-to-many or many-to-one. By using symbolic language or interpreting events in a meaningful way, generative leaders can communicate to groups in ways that allow individuals to experience the communication as personalized.

For example, visionary and charismatic leaders make personalized appeals to establish purpose through symbolic language (Burns, 1978; Bass, 1985; House and Aditya, 1997; Sashkin and Sashkin, 2003). This reduces complexity by enabling individuals to share cogent ideas about the opportunity within a common language while less impor-

tant informational elements, such as irrelevant facts and spurious speculations, are repressed and therefore do not add complexity to the exchange. A clear implication for successful innovation projects is that observation, sensemaking, and sensegiving (Weick, 1979) skills are critical aspects of generative leadership.

Likewise, generative leaders set the stage for interactions and promote clear and effective communication between groups and individuals that reduce and absorb complexity. The use of whiteboards, "War Rooms," and brainstorming technologies are all means to foster clarity in one-to-many and many-to-one communication interactions while limiting signal noise in complex interaction environments to reduce complexity (Davila *et al.*, 2006). For such interactions to lead to fruitful results, they must absorb complexity and involve messages that simplify and synthesize details to signify value to relevant agents. Thus, communication must evolve to the point that agents use the same language; often a new language or code must be adopted or invented for this purpose (Lane and Maxfield, 1996). Therefore, generative leaders focus on helping to evolve a language that evokes meanings that are well understood in the organizational context. As a result, because the number of people able to understand the context is increased, the capacity of the organization to absorb complexity is enhanced (Boisot and Child, 1999). Consequently, even lower-level members of the organization can contribute to innovation, corroborating Burgelman's (1983) contention that successful bottom-up innovation depends on promoting such interactions.

Interaction alignment

Interactions must also be aligned toward the achievement of system goals so that knowledge gained through interactions can be selected and applied to problem solving. Generative leaders ensure that goals are specified in advance to ensure that all group members participating in the innovation project are aware of them. For example, a system-wide or firm-level goal may be to attain the technological frontier and achieve the identity of leading innovator; goals of individual organizational units or sub-systems could include improving the speed of project implementation, reducing costs, or enhancing safety. By making these param-

eters explicit early in the project, project teams can incorporate these goals into the overall innovation solution.

Interaction speed

Generative leaders exhibit openness to collaboration and emphasize the use of technological tools that enhance the effectiveness of connections and interactions. Increasing the speed of interactions raises the amount of information available within a given period to enhance problem solving and task performance. However, the risk of overloading the system presents a design problem in complex systems that are tightly integrated (Rivkin, 2001), since bottlenecks in information processing can cascade throughout the system. A solution is to upgrade system capabilities to enable speedier information processing via the adoption of new communication technologies.

For example, multinational corporations have adopted enterprise resource planning (ERP) systems to connect and coordinate various sub-systems worldwide via technology. Such technologies not only increase interaction speed but reduce complexity by standardizing processes, while disseminating information more rapidly to relevant parts of the system and maintaining a high degree of connectivity between various system components. Technology facilitates real-time interactions between sub-systems, including those that are geographically distant. Wal-Mart's state-of-the-art information-processing systems provide the company with superior operational capabilities that competitors find difficult to match. New technologies thus enhance complexity absorption and permit rapid interactions.

Interaction partitioning

Generative leaders focus their attention to allocating resources dynamically across sub-systems and operate to manage the interfaces between them. By adopting modular organizational systems (Baldwin and Clark, 2000) that are loosely coupled (Weick, 1977), generative leaders help to limit the impact of interactions to a subset of the system when conducting experiments, and thus limit the consequences of mistakes or underdeveloped ideas that may result in complexity catastrophes. Modular systems thus allow the system to develop and retain more variations that may prove useful in future innova-

tion and problem-solving exercises. Generative leaders also recognize that complex tasks must be sub-divided into simpler tasks and performed in independent modules to enable collaborative interactions without overloading the system. Therefore, they encourage parallel experiments to be carried out independently without adversely affecting the system while ensuring adherence to quality and other relevant parameters for sub-system output.

However, partitioning interactions may constrain communication and inhibit opportunities for further novelty. Generative leaders guard against these constraints on innovation by ensuring that evolving needs inform partitioning decisions and that partitioned sub-systems remain linked to the information flow through periodic information exchange. Modular systems of this type are prevalent in automotive manufacturing firms and software firms (Baldwin and Clark, 2000).

Interaction leveraging

Interactions that yield significant information or insights leading to innovation are a scarce resource. Generative leaders ensure that this resource is leveraged effectively by retaining and reusing knowledge or ideas generated through such interactions in other interactions in a wide variety of contexts. Examples of methods to leverage knowledge include re-using team experience in different projects or sub-units (Surie, 1996), embedding knowledge from interactions in methodologies, tools, and other artifacts that can be used by others (Wenger, 1998), and disseminating knowledge wherever required in the system via training (Surie, 1996).

As described above, generative leaders manage complexity by encouraging innovation-inducing interactions while simultaneously reducing and absorbing the resulting complexity. Partitioning and leveraging interactions and using technology to speed interactions are mechanisms for reducing complexity by codifying and replicating knowledge. On the other hand, establishing centers of excellence, accumulating pockets of expert knowledge, and encouraging relationships that make this knowledge accessible to others are ways of absorbing complexity. Generative leaders focus on both to leverage resources generated from each set of interactions by diffusing and re-using them in as many new projects as possible. Figure

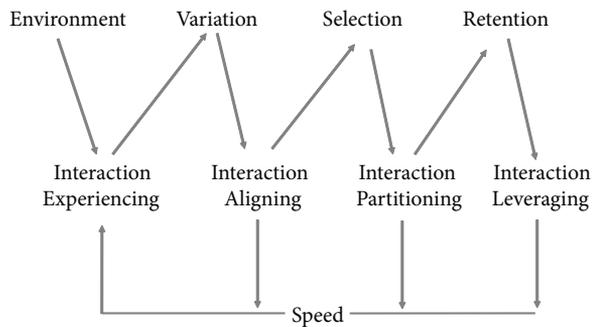


Figure 1 *The evolution of innovation and organizational capabilities: Leadership regulates complexity as interactions generate, select, and retain variations*

1 provides a schematic view of how the various dimensions of interactions help innovation and the evolution of capabilities.

Institutionalizing innovation

In addition to setting the stage to enable and regulate interactions, generative leadership also enhances problem-solving capabilities by institutionalizing innovation both in sub-systems and in the system as a whole. Hence, generative leaders must evolve and enforce rules that govern the system's dynamic use of information generated through interactions to facilitate problem solving. We outline three rules followed by generative leaders that help to create routines for innovation.

First, interactions *per se* do not facilitate problem solving unless they reveal information relevant to the task or make salient certain features of the problem. Hence, interactions must be structured so as to yield a representation of the problem to be solved by enabling group participants to parse the problem into its component features (Holland, 1995); in other words, the rules must serve to bracket relevant experience for the participants (Weick, 1979).

Traditional perspectives on leadership focus how leaders' behaviors help to establish and articulate vision, strategy, or objectives and mobilize followers. Generative leadership, in contrast, focuses on structuring the context and system to enable organizational or group members to analyze or represent problems accurately from multiple perspectives, while avoiding the risks inherent in insular, self-referential environments. At a system level, generative leaders are catalysts that help to

capture diverse perspectives and focus attention on salient features of the environment and multiple dimensions of a problem. At a sub-system level, new product generation requires that innovation teams seek to identify and conceive the problem in new ways by focusing on key outcomes and constraints. Generative leadership is thus exercised at all levels of the organization to catalyze this process. Consequently, generative leaders help to change the system-environment model by focusing attention on the constraints and possibilities of the market and context.

For example, by focusing on constraints in developing countries such as the need to conserve fuel, coupled with poor roads and lack of space, small cars suitable for crowded conditions were developed. Similarly, recognizing the potential of a market for consumers with low discretionary income led to a focus on making cheaper computers and cell phones; this involved representing the problem of creating novel products differently. Rather than focusing solely on technology, generative leaders are sensitive to the nuances of social conditions and the needs of the context.

Second, since group interactions must culminate in action based on a match between the model or representation of the problem and the environment, generative leaders focus on gaining rapid feedback through action. In contrast to traditional perspectives that conceive of leaders as the gatherers, interpreters, and synthesizers of feedback and as those who heroically convert the information into a strategy or vision, generative leadership channels feedback through the organization's members who are in the best position to interpret and synthesize the new information into ever more useable models of the environment. The accuracy of the representations thus formed can be judged by acting on the basis of their predictions and determining whether the predictions match the state of the world (Holland, 1995). In fast-changing environments, frequent action is necessary to check whether a representation is accurate (Eisenhardt and Jeffrey, 2000). Subjecting prototypes of a new product or service to market tests at different stages of the innovation life cycle helps to gain rapid feedback and update the organizational representation of the problem. These rapid iteration and feedback dynamics based on insight drawn from both internal and external interactions are shown in Figure

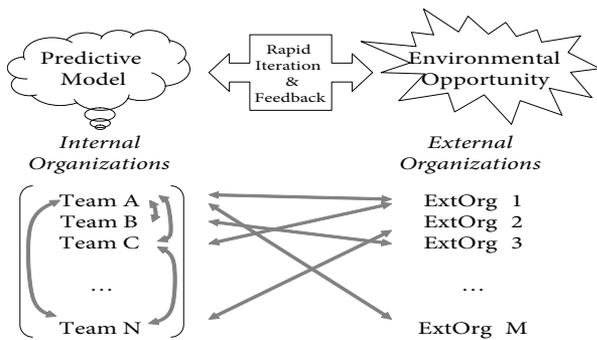


Figure 2 Innovation dynamics leverage internal and external interactions to match predictive models to opportunities via rapid interaction and feedback

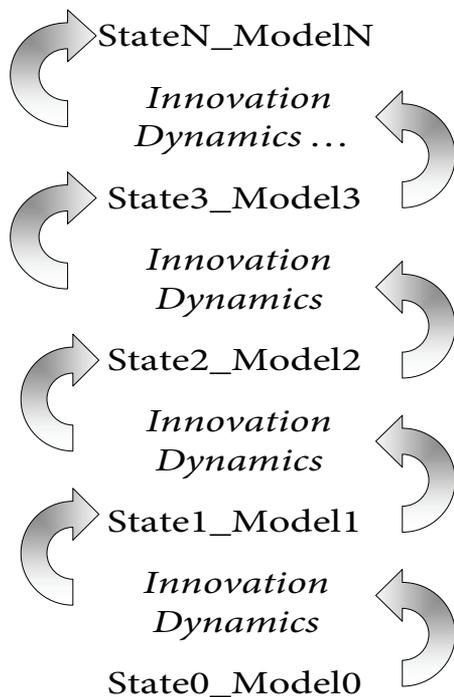


Figure 3 Institutionalizing innovation: Capability configurations are improved to sustain fitness-enhancing innovations

2.

Third, generative leaders emphasize using a disciplined procedure for continuing or stopping innovation projects depending on the likelihood of success or failure. Consequently, they focus on tracking outcomes via milestones that evaluate the progress of the innovation project on its own terms. This is in contrast to traditional approaches that evaluate a project based on its perceived contribution to a predetermined strategy. Besides relying on exit strategies such as divestment in case of

failure at the end of a project, generative leaders use interim milestones like those described above to help reconfigure and reallocate resources rapidly and minimize waste in case an innovation project is unlikely to succeed. In contrast to traditional models of leadership, generative leadership emphasizes rapid learning and help to evolve rules for proceeding at different stages of an innovation project, thus helping to mitigate the uncertainty inherent in innovation.

A key feature of any evaluation process is evolutionary selection: the ability to learn continuously and implement learning in action as the project proceeds. Thus, generative leadership explicitly encompasses learning and evolution. A case study of generative leadership in an Indian automotive and farm equipment company is presented below. Figures 2 and 3 present an outline of innovation and institutionalization processes.

A case study of generative leadership in an Indian automotive manufacturer

This case study was conducted by the first author as part of a larger study on capability building and innovation in the context of foreign technology adoption by Indian firms. Interviews were conducted between 1993 and 1996 with senior executives involved in technology transfer at the corporate headquarters, and at the engine manufacturing plant with manufacturing and R&D heads and other managers. Subsequent details are obtained from published sources (annual reports from 1996 onwards, and websites; the name of the organization has been disguised for confidentiality).

Liberalization of the Indian economy in the wake of India's financial crisis in 1991 led to the abandonment of post-independence economic policies of import substitution and infant industry protection, in favor of policies focused on exports and reducing barriers to entry to foreign firms (Jalan, 1991). Competition from multinationals led domestic firms to seek a solution to the problem of how to compete globally and participate in world markets. Interactions with foreign firms supplying technology can thus be viewed as learning experiments situated within an environmental context of transition from a closed to an open economy. External circumstances prompted many leading domestic firms to exercise generative leadership by

emphasizing system-wide innovation and problem solving in response to external challenges.

IndiaMotors, a manufacturer of utility vehicles and farm equipment, had entered a technical collaboration with a French company in the mid-1980s to manufacture automotive engines in India, a relationship that continued into the 1990s. Project leaders exercised generative leadership by ensuring that the relationship between the French supplier of technology and the Indian recipient was structured to nurture collaboration and foster capability building in the Indian firm.

Regulating complexity

Interaction experience

The environment in IndiaMotors was structured to achieve both complexity reduction and absorption by codifying tacit knowledge and standardizing information flow in relationships between different internal and external sub-systems. Managers in IndiaMotors reported that their relationship with the Japanese technology supplier was open and supportive; the French supplier provided technical information and process know-how on a timely basis, and adopted a mentoring stance toward the Indian collaborator, even helping with testing components and processes in India to ensure that the product met international quality standards.

Within IndiaMotors, top management, departmental heads, and project leaders exercised generative leadership by ensuring that inter-departmental relations followed protocols of cordiality. Managers collaborated during a labor strike to study internal processes and innovate improvements to the layout of the factory to improve efficiency. Managers also understood the value of using mechanisms such as cross-functional teams and had adopted such practices by the mid-1990s. By including members of all departments at the outset of a new project, the company was able to pool expertise and rapidly disseminate information relevant for accomplishing the task of manufacturing equipment based on new technology. Top management also reduced complexity by using symbolic communication that included appeals to help the organization survive and compete against competitors by emphasizing goals such as the need to achieve international quality standards.

Interaction alignment

Interactions between the manufacturing plant and other departments such as R&D and corporate were aligned to promote information flow at every stage of the work flow; this reduced complexity and enabled the company to increase responsibility at each stage of the hierarchy, so that even workers on the shop floor were aware of the need to improve quality and productivity. Moreover, because objectives were clear, each department was responsible for monitoring its own actions and for seeking feedback by benchmarking performance against agreed standards. Standard tools used by companies worldwide were employed to align goals. Although the idea of a hierarchy was not abandoned, complexity was absorbed as junior engineers could gain access to top levels of management and thus expert knowledge sources in order to address problems that could not be handled at lower levels.

Interaction speed

New communication technologies were widely adopted to speed interactions and communication. Since communication by telephone and facsimile machines was the only option during the early phases of technology adoption, face-to-face interactions were necessary. Later, the adoption of email, intranets, and other technologies permitted the firm to standardize information and speed interactions between organizational sub-units, international partners, and local suppliers. Also, computer-aided manufacturing systems allowed all parts of the organization to be instantaneously linked and speeded interactions with overseas technology suppliers. Despite the potential for overwhelming the system by increasing the speed of interactions, complexity was managed by substituting face-to-face communication with asynchronous communication. This permitted large amounts of data to be processed offline and enhanced the efficiency of communication.

Interaction partitioning

In 1999–2000, the company adopted a new business model that leveraged the internet to improve connectivity and provide interfaces between all modules involving different stakeholders of the organization, such as dealers, vendors, and customers. Computerized systems were also installed in the late 1990s to ensure smooth integration across

marketing, design and production sub-systems and intranets were used to manage knowledge more efficiently in the different independent projects embarked on. As more resources were generated, new projects could be pursued concurrently in new markets by diversifying into engineering services, automotive components, information technology, trade- and finance-related services, and infrastructure development.

Interaction leveraging

Learning from interactions with technology suppliers and in other implementation and technology-adaptation situations was preserved through practice, participation, and training both in India and France. Selected employees were sent for training in France and some Indian suppliers were also provided with training in France by the suppliers of the French partner. French experts provided assistance in tools, component validation, and testing.

When production began in India, all components were sent to France for validation and testing. The French also provided help in developing systems and the approach to be used in relevant areas of manufacturing. This knowledge was diffused within the organization and shared with suppliers. Similarly in design, R&D engineers leveraged their learning from suppliers' designs and drawings in working with design consultants to modify borrowed designs to suit local conditions. At the system or organizational level, quality control and benchmarking programs were implemented to achieve international standards and diffused to local suppliers.

Institutionalizing innovation

By focusing on adopting new technology and new practices to manufacture engines indigenously, members of the organization developed a new representation of the problem of innovating to compete in world markets. This involved tapping knowledge from a variety of sources, including workers, customers, and suppliers, rather than limiting innovation and new product development to in-house R&D engineers. As a result of reconfiguring the organizational system through interactions with French experts, a problem-solving lens emerged. Testing, diagnosis, and evaluation were applied to manufacturing, and dominated every sphere of activity including planning, proto-

type construction, quality, materials, and supplier development. A quality orientation also emerged and design changes in the excavator were triggered by monitoring the performance of excavators in use. By 1995 business process reengineering was introduced in the division and the engine plant obtained ISO 9002 certification from TUV of Germany, signaling the firm's intent to be regarded as a top-quality manufacturer aspiring to world-class standards.

Organizational leaders exercised generative leadership by testing this emerging representation of a world-class manufacturer through initiating other projects and forging other alliances. In 1996 a new light commercial vehicle was launched; all engines types were approved for new emission norms; and an integrated design and manufacturing center was established to design an entirely new vehicle with the help of internationally renowned consultants. In 1997, the firm entered a manufacturing alliance with a leading American automotive manufacturer and a technical alliance with a Japanese one. By 2002, a new-generation sports utility vehicle was launched and in 2004 exports of two vehicles commenced to Latin America, the Middle East, and South Africa.

Successes in domestic and export markets led the firm to enter joint ventures with another French collaborator to manufacture a mid-sized sedan, and with an American company to manufacture trucks and buses in India. The company is currently one of the leading manufacturers of utility vehicles and farm equipment in India, with revenues of \$2.59 billion in 2005.

The emergence of system-wide innovation at various levels in this organization suggests that promoting innovation need not be a top-down exercise. Rather, exercising generative leadership requires wider diffusion of problem-solving efforts through enhancing connectivity and interactions by regulating the environment in which innovation occurs.

Conclusion

This article uses a complexity science perspective to posit a framework for generative leadership that helps to foster innovation. Our view of generative leadership contributes a new perspective on leadership by drawing attention to structuring the overall context of innovation and

suggesting how system-wide innovation is stimulated. Our framework outlines how generative leaders can influence five aspects of interactions to enhance system capabilities for innovation and three processes for institutionalizing innovation. In addition, our view of generative leadership suggests that the capacity to solve problems and innovate is widely distributed in organization systems and can be harnessed only through concerted efforts to both increase and regulate interactions to facilitate knowledge recombination. Moreover, rather than focusing on individual interactions between leaders and followers, our perspective on generative leadership emphasizes the *organizational* capacity to enhance connectivity, and thereby promote innovation by synthesizing and recombining ideas from different parts of the system and adapting them to fit a changing and dynamic context.

Our framework is supported by evidence from a case study of new technology adoption and innovation in an Indian automotive manufacturing firm. Despite the limitations of a case study of one organization, details from the case and examples provided for each element of the framework support our perspective. March *et al.* (1991) note that organizations often learn despite very limited experience – a sample of one – because they augment the experience by attending to different aspects of it. In addition, they argue that the richness of history can be enhanced by focusing on critical events; three aspects of events render an event critical. First, events located at important points in history that change the world are critical. Second, events that change what is believed about the world are critical. Third, the metaphorical power of an event makes it critical – events that evoke meaning, interest, and attention are critical. Based on these criteria, we argue that innovation and capability building in the context of technology adoption by the automotive manufacturing company via interactions with foreign technology suppliers is a critical event, since it evoked a change in the organization's representation of itself, aroused widespread interest and meaning, and was located at a critical juncture in the history of the firm and the nation. By analogy, we can learn from details yielded by a sample of one, just as organizations do.

Nevertheless, our understanding of generative leadership can be enhanced by further testing this framework through more case studies, large-

sample studies of innovation, computer simulation models, and laboratory experiments. The concept of generative leadership and its effect on innovation via the management of complexity raises new research questions for investigation, such as:

- Are all mechanisms for regulating complexity through the structuring of interactions absolutely essential to facilitate innovation or is there a minimum set?
- What is the impact of each mechanism and how can they be measured?
- Is there a variation in the types of larger systems that emerge from structuring interactions? What are the competitive attributes of these different emergent forms?
- Does elimination of interactions and connectivity lead to a cessation in innovation?
- Do simple rules for institutionalizing innovation lead to the emergence of complex structures over time? What are these rules? How do rules evolve? What kinds of trajectories can we anticipate based on these interventions?

These questions can be best answered through a combination of historical studies of the evolution of organizations (Surie, 1996, 2003); laboratory experiments that generate detailed information on interaction strategies and rules to yield insights on generative leadership; and studies that use computational techniques such as variants of Kauffman's NK model, system dynamics, or agent-based modeling techniques (Hazy, in press), to simulate the impact of interaction management and complexity on innovation.

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