The Complexity of Social Interactions: Organizational Change and Performance

Assist. Prof. Desmond Ng
University of Alberta,
Department of Rural Economy
515 General Services Building
Edmonton, Alberta, Canada
T6G 2H1
Phone: 1-780-492-0819
Fax: 1-780-492-0298
Email: desmond.ng@ualberta.ca

Manuscript Presented and Submitted to
Managing the Complex IV: Conference on Complex Systems and the Management of Organizations.
Manuscript submission for Emergence (Word Count 5196)
kurt@kurtrichardson.com

Desmond Ng: Biography

Desmond Ng is an assistant professor of agri-business & strategic management at the department of Rural Economy at the University of Alberta. He has received his doctorates in Agricultural Economics with specializations in Agri-business and Strategic Management at the University of Illinois at Urbana-Champaign. His research focus concerns the study of firm and inter-firm performance (i.e. social networks) in dynamic markets. This includes development and applications of Austrian entrepreneurship and Complexity theories / methods to agri-food management, such as, entrepreneurial and innovation strategies in value chain networks, competitive strategies in knowledge driven economies, structural change in supply chain systems. He teaches undergraduate courses on agri-business management, agri-business strategy and competitive market structures.

The Complexity of Social Interactions: Organizational Change and Performance

Abstract

One area of considerable and growing interest related to complex adaptive systems concerns applications of complexity principles to strategic management research. Despite the increasing popularization of complexity thinking to strategic management, there has been frustration with the generality and ambiguity towards understanding organizational change in complex environments. Extensions of complexity principles to social science investigations often rest upon the supposition that the complex properties and behaviours of the natural and physical world naturally extend to the world of social science. It is argued that the development of complexity approaches to management research needs to develop under the conditions and context unique to one's investigative domain. Based on complementary theories, a 'socially' complex framework of organizational change and performance is proposed. This framework posits that the strength of complementary relations (S), organizational power (P), and organizational diversity (D) are key social elements that dictate the extent of organizational change and performance.

The Complexity of Social Interactions: Organizational Change and Performance

Introduction: Complexity in Social and Physical Sciences

Social systems –albeit organizations, industry groups, markets, institutions - have long been characterized by social scientists as complex entities. From the Scottish philosophers of Hume, to Adam Smith and Austrian economist, Hayek, markets were viewed as complex systems with spontaneously emergent or market ordering properties. Although developed under the domains of natural and physical sciences, Poincare and later Prigonine were principal to the development of what is called the emerging field of complexity science (Rosenhead, 2001). Although there is no general consensus on the definition of complexity, complex systems are often described as systems containing numerous interacting subcomponents whose interactions yield complex behaviours of chaos, order and edge of chaos (Jantsch, 1980; Kauffman, 1995). With the increasing uncertainty and turbulence of modern markets, management practitioners and social scientist have drawn upon the properties and principles of complex biological and physical systems to better explain social systems as complex adaptive systems (Brown and Eisenhardt, 1998; Levinthal and Warglien, 1999; MacIntosh and Maclean, 1999; Marion, 1999; Mathews et al, 1999; McKelvey, 1999; Stacey, 1995).

Despite the increasing popularization of complexity thinking, the development of complexity perspectives to understanding organizational change and performance is limited. One of the great themes in social science has been the study of organization change and performance. It represents a distinct departure from static and mechanistic design models of management in which organizational change requires a more concerted focus on dynamic processes in spatial and systemic terms (Farjoun, 2002; Pettigrew et al, 2001). As complexity science is distinguished by its study of system behaviour that consists of interdependent elements (Jantsch, 1980; Kauffman, 1985; Levinthal and Warglien, 1999), it provides a potentially unique approach to understanding the dynamic and spatial processes that impact organizational change development.

An area of change management research that underscores systemic interactions that impact organizational change and performance is complementarity theories (Dyer and Singh, 1998; Levinthal, 2002; Matsuyama, 1995; Whittington et al, 1999; Teece, 2000). Complementary theories have a holistic orientation in which it 'insists on a simultaneously aggregated and disaggregated analysis, both to define the conditionality of individual effects on other effects and to ensure full system effects outweigh individual component effects" (Whittington et al, 588,1999).

Based on complementary theories, a 'socially' complex framework of organizational change and performance is proposed. This entails an explicit attention to the spatial and dynamic dimensions of organizational change where the structures of social networks are utilized to understand organizational change in complex environments. In drawing upon the burgeoned interests in social network perspectives, it is argued that the nature of complementary interactions are intricately related to one's social network structure which in turn is proposed to impact the performance and change behaviour of organizations. This is examined by the S (Strength) P (Power) D (Diversity) framework. This framework forwards complexity

perspectives in not only addressing one of the key challenges of strategic management, but offers a potentially attractive alternative to the traditional "mechanistic and design models" (Farjoun, 2002) of strategic management.

Conceptual Foundations

The concept of complementarities has been increasingly recognized as a source of inter-organizational rent (Dyer and Singh, 1998; Graff, Rausser & Small, 2001; Levinthal, 2002; Powell, Koput, Smith-Doerr, 1996; Teece, 2000). Complementarities -as described under numerous terms such as the positive cross marginal productivity of capital (Graff, Rausser & Small, 2001; Lewin, 1997; Whittington et al, 1999), synergies or complementary resource endowments (Dyer & Singh, 1998), complimentary assets (Teece, 2000), and complementary capabilities (Adler & Kwon, 2002) rent- rests on an underlying assumption that the resources and capabilities of a firm are heterogeneous. An argument promoted earlier by the Austrian economist Lachmann's (1947). Lachmann's theory of capital abandons assumptions of homogenous capital in which capital in a market is viewed as an evolving structure (Lachmann, 1947). The capital goods or resources of a firm are structured in a spatially complex pattern where changes in the productivity of one good can have unpredictable effects on the capital structure of the market (Lachmann, 1947). This heterogeneity imparts internal and external complementary relations. Hence, in the presence of complementarities, the competitive performance of resources held with in a firm depends on other resources used within the firm as well as in conjunction with resources of other firms (Teece, 2000; Teng and Cummings, 2002). Through a process of recombination, complementarities result in "a synergistic effect whereby the combined resource endowment were more valuable, rare and difficult to imitate than they had been before they were combined" (Dyer and Singh, 667, 1998). Hence, sources of wealth creation are not exclusive to the internal resources of the firm, as championed by the ubiquitous Resource Based View (RBV) but rather a 'holistic' or systems orientation that emphasizes both internal and external social network relations as pivotal to competitive performance (Dyer and Singh, 1998; Teng and Cummings, 2002).

Conceptual Model of Organizational Change and Performance

As complex systems are often depicted as a system of heterogeneous and interacting elements (Jantsch, 1980; Kauffman, 1995; MacIntosh and Maclean, 1999), the heterogeneous and resulting complementary interactions (internal and external to the firm) is instrumental to investigating the complex properties found among such social interactions. Specifically, a socially complex system consists of widely dispersed organizations with varying heterogeneous resource capabilities in which their complementary interactions create complex dynamics that influence the magnitude of organizational change and performance. Specifically, based on the notion of complementarities, an S-P-D framework is proposed that identifies three social structural factors that determine organizational change and performance. The S-P-D framework proposes that: 1) the strength (S) of complementary relations (internal and external to the firm), 2) organizational Power (P), and 3) organizational resource Diversity (D) impact the type of organizational change (incremental or radical), and the sustainability of organizational performance. The components of the S-P-D framework are described as follows:

Strength of Complementary Relations (S)

In defining the strength of complementary relations, they are defined with respect to the number of internal and external complementary interactions. Firms with strong and weak complementary relations are defined as firms with a high and low number of complementary interactions (internal and external), respectively. Stated in the language of complex fitness landscapes, the number of internal and external complementary interactions is analogous to Kauffman's (1995) notion of 'epistatic' couplings, as seen in his examination of NKCS fitness models. Specifically, the number of internal complementary relations is analogous to the K espistatic couplings of NKCS fitness models. K epistatic interactions refer to the number of interactions among genes of an organism that determine an organism's overall fitness. The internal complementary interactions between the resources of a firm exhibit such inter-relationships in which their combined influence contributes to non-linear performance gains (Dyer and Singh, 1998). In addition, according to Kauffman (1995), the C epistatic interactions refer to epistatic links that are external to an organism. This can be similarly cast in terms of external complimentary relations. In spite of such similarities to Kauffman's fitness landscape, one important distinction is that these epistatic links are endogenously determined by the pattern of firm resource choices in the market place. This follows directly from Lachmann's (1947) theory of capital structure where such a structure evolves with changes in the plan choices of subjective individuals. Since Austrian economist, Lachmann, views individual choices to be primarily subjective (Lachmann, 1977), one cannot predict the changing use of capital and their resulting complementary or epistatic relationships. The capital structure and the incentives that define such a structure is therefore, endogenously driven by the subjective changes in knowledge experiences. While according to fitness landscape models, an organism's fitness and their epistatic couplings are often exogenously determined. In social systems, they are not.

With this characterization, the strength of a firm's complementary relations (S) directly impacts the type and duration of organizational change. When conducting organizational change initiatives, firms with strong complementary relations are more likely to conduct radical changes than those that do not. For external relations, the reasoning is that strong complementary relations will strongly impact the complementary relations to other resources used by other firms. For instance, the implementation of food brands containing information traceable attributes (i.e. origin of production, use of genetically modified inputs, animal welfare practices, production practices involving absence or use of pesticides, etc) at the food retail sector directly impacts upstream members (farmer producer and food processors) of the food value chain in terms of the use of information technology systems. This includes the use of identify preservation systems that trace food information attributes from farm production to food processing, food production and distribution logistics involving food handling protocols that prevent commingling of attribute specific food product with non attribute specific food groups. Complementarities internal to the firm are also another important dimension. Teng and Cummings (2002) state that understanding the interrelationships of resources across functional areas of a business need to be understood in systemic terms otherwise exclusive attention to key core competences in one area can unintendedly diminish other competencies held by a business. For instance, the competitive advantage of the grocery chain Food Lion relied exclusively on cost control but failed to develop other resources with in the value chain, such as relationship capital (Teng and Cummings, 2002). When resources are highly interrelated, piecemeal or incremental changes in one aspect of a firm's organization –such as improvements in cost efficiencies- can un intendedly affect other

resources (i.e. relationship capital) held by a firm. By understanding these interdependences -in systemic terms- changes in resource use will not be done in isolation but will rather involve changes in the overall resource configuration of the firm (Teng and Cumming, 2002). This is because changes in one resource or area of core competence would require concurrent change in other resources of the firm. For instance, the development of film based instant photography (Polaroid) required the redesign of the camera and film, and recent developments automobile design such as the 'skate board' auto chassis by General Motors requires fundamentally different requirements in car body construction. Such changes as argued by Teece (2000) lead to 'systemic innovation' where changes in one part of the system impacts adjustments to other parts of the system. Whittington et al's (1999) empirical research also supports the notion that organizations with high complementary assets have tendencies to undertake large scale –as oppose to piece meal incremental changes. In addition, since the strength of complementary relations is likely dependent on the proportion of firm resources that are sensitive to internal and external complementarities[1], resources sensitive to such relations will more likely be subject to radical organizational changes (Dyer and Singh, 1998). Taken together, increasing complementary relations increases a firm's susceptibility to radical changes.

As organizational change is a process of combinatory search (Levinthal, 2002; Matsuyama, 1995), this radical change provides search over a greater space of potential complementary configurations than would not have been possible with incremental /piece meal change. As a result, the strength of a firm's complementary relation positively influences the likelihood of radical change and subsequently reduces the duration or time required in finding desirable performance outcomes. In increasingly competitive and dynamic markets, this ability translates into more rapid responses to the development and adoption of new technologies and thus can be a source of competitive advantage. However, at the same time, radical innovative changes also invite greater degrees of risk, such as first-mover (dis) advantage. Hence, although increasing complementarities can increases organizational performance, the variability in performance is also increased.

Organizational Power (P)

Although the strength of complementary relations underscores the degree to which organizational resources are interrelated –internally and /or externally, these relationships are also subject to asymmetrical or non-uniform influences. The strength of complementary relations determines the span of influence that organizational resources have in impacting the internal and external resource choices of network members. Some of these complementary relations can impact network members more so than others because certain combinations of resources can impact network members differentially. For instance, organizations holding a large proportion of assets that are co-specialized with resources of other firms are impacted differently than firms that are not. In life science industries, such as in crop, seed and nutraceuticals, key commercializing assets in terms of processing and production technologies that utilize gains in scale economies, distribution and transportation logistics and market branding are held by larger life science companies. These assets are instrumental to commercializing the possibilities from basic R&D innovations of smaller start-up biotechnology firms (Kalaitzandonakes and Bjornson,

1 As inter-firm relationships are increasing recognized by management scholars as an important but neglected area of investigation (Dyer and Singh, 1998), the arguments pertaining to the strength of complementary relations will emphasize external complementary relations.

1997; Teece, 2000). As a result, the strength of complementary relations needs to also include the asymmetrical aspects found within each of these complementary ties.

The asymmetrical aspect of complementary relations is cast in terms of the influence of organizational power with in a social structure. Socio-economic researchers have argued the structure of social networks impacts organizational behaviour (Kraatz, 1998; Pfeffer and Salancik, 1978; Powell, Koput, Smith-Doerr, 1996; Smelser and Swedberg, 1994). According to Resource Dependence theory (Thompson, 1967; Pfeffer and Salancik, 1978), organizations are embedded in an environment consisting of other organizations to which they depend upon those organizations for those resources that they require. Organizations are dependent on the external environment in which this includes resources held by outside actors. As such resources impact the survival of organizations, focal organizations are confronted with the problem of controlling for such inter-dependencies. Thus, organizational power is a form of inter-organizational control that 'involves a process in which both the influencer and the focal organization act to affect the conditions governing the influence process" (Pfeffer and Salancik, 45, 1978).

Organizational power reflects an asymmetric relation of unbalanced reciprocity and is measured by social network measures of centrality (Burt, 1992; Powell, Koput, Smith-Doerr, 1996). Following from Resource Dependence arguments, firms with complementary resources, especially in conjuction with strong external complementary relations[2], should exert greater power and control of the use of resources made by other network members. That is to say, organizational power is directly influenced by the degree at which its resources are complementarity to external members. For instance, in the development of VCR standards (Beta and VHS) (Cusumano, Mylonadis and Rosenbloom, 1992), JVC, the developer of the VHS standard formed a strategic alliance with its parent firm, Matsushita, to exploit its generic skills in mass production and distribution. In addition, alliance with peripheral component producers (i.e. users and producers of VHS tapes) was instrumental to the VHS dominance. The underlying complementarities found between JVC and Matsushita's production and distribution exhibited considerable influences to peripheral component players that led to the eventual dominance of the VHS standard. Therefore, organizations with complementary resources are likely to enforce power among network members by rendering network members dependent upon the complementary resources held by the focal organization. By nature of their influence, such an organization can set the terms of resource use with in a network in a manner that reinforces their central position. Thus, organizational power tends to increase organizational performance. In addition, due to the centralized network position, power provides the focal organization information rich positions allowing such a firm more timely access to new technologies and resources. Powell, Koput, Smith-Doerr's (1996) empirical study of inter-firm collaborations in the biotechnology industry supports such a position whereby organizations located in central network positions are more likely to derive performance gains from the assimilation of inter-firm knowledge experiences, and obtaining R&D collaborations. In addition, organizational power also derives further performance enhancements through network externality effects. Within a network, complementary resources are subject to self-reinforcing effects or cumulative complementary influences (Matsuyama, 1995). For instance, computer hardware and software are complementary industries where, in a self-reinforcing fashion, product development in one positively supports the sales of the other.

[2] As described latter, the strength of complementary relations serves to increase this span of organizational control.

With respect to organizational change, since power yields a certain control of the resource configurations of external members, and give that the external members' resource choices contribute to the performance of the focal organization, power can create 'inertial or lock in' (Arthur, 1989) behaviours. This mitigates radical organizational change. In the parlance of complexity terminology, power is a form of non-linear negative feedback that drives ordering tendencies in the capital structure. Organizations subjected to the power influences of a focal organization are coerced into choosing those resources configurations that support the power position of the focal firm. The formation of complimentary resource configurations among network members can create alliance specific exchange relations that are resistant to change (Dyer and Singh, 1998). As a result of organizational power, a form of strategic myopia can result from these complementary relations. Therefore, due to the inertial tendencies that support the central position of the focal organization, organizations subjected to power influences are expected to undertake incremental changes and that such changes occur over prolonged periods. More over, according to Institutional perspectives, radical changes constitute non-legitimized organizational forms (Scott, 1995) in so far as they are not sanctioned by organizations of power. Radical changes are resisted as it fundamentally alters the complimentary resource configurations among network members and, thus, erode the basis of organizational power. Because of these influences, organizational power will tend to create more coordinated capital structures. Hence, unlike Lachmann's 'radical subjective position' that contends markets are in continued dis equilibrium (Lachmann, 1977), organizational power creates tendencies towards the coordination of resources that exploit structural complementary arrangements[3].

Organizational Resource Diversity (D)

In so far as organizational power positively influences the performance of organizations, the sustainability of organizational performance is contingent on the diversity of resources employed. In building upon the assumption of resource heterogeneity, the diversity of organizational resources is defined in terms of organizations with multiple divisions (i.e. functional divisions or strategic business units) with diverse areas of competence. Organizations with strong resource diversity will tend to create 'transitive' or 'closed' networks. Transitivity refers to tendencies where 'two individuals who are both tied to a third are to also be tied to each other' (Feld, 1022, 1981). Stated alternatively, transitive networks tend to yield the formation of a closed cluster where each individual is connected directly or indirectly to other individuals in the network. Transitive networks can lead to the formation of group identities or group community structures (Nahapiet and Ghosal, 1998). Transitivity can occur when an organization's resource diversity increases. This is because increasing the heterogeneity of organizational resources increases the likelihood that resources exhibit complementarities with the resource used by network members and thus this increases the likelihood of forming a transitive network. This transitive network reflects an 'ideal' state described by Lachmann's capital structure, where each plan is directly or indirectly complementary to every other plan in the market (Lachmann, 1947, 1977).

Membership with in such a networks confers sustainable and performance enhancing effects. With this 'closed loop' of complementary relations, the resources of each firm reinforce

3 This is of central importance to the Austrian economic debate on the equilibrium and disequilibrium tendencies of markets.

the performance of other firms in this transitive network[4]. This has a tendency to derive direct and indirect synergistic effects from this 'closed network' structure in which given the closed network structure it serves to increase and sustains network performance. With such incentives, this reduces the incentive for firms to deviate from those complementary resources dictated by this closed network structure.

S-P-D Interactions on Organizational Change and Performance

In summarizing the arguments of the S-P-D framework, figure 1 shows the relationship between the arguments of the S-P-D framework and its impact on organizational change and performance. As expressed by Whittington et al (1999), organizational performance and change is expressed in terms of a J curve relationship. This J curve relationship shows organizational performance and the magnitude (incremental vs. radical) of organizational change[5] is influenced directly and collectively by the three arguments of the S-P-D framework. These interrelationships are explained in the following discussion:

[Insert Figure 1 Here]

Strength and Power

The strength (S) of complementary relations (internal and external to the firm) has a tendency to amplify the effect of organizational power (P) on organizational performance and increase tendencies for incremental change. Increasing the strength, especially in terms of external complementary relations, increases an organization's power of influence among network members. That is to say, the 'organization's field' (Scott, 1995) of influence or span of control is extended by increasing the number of complementary relations to network members. From institutional theory, Scott (1995) defines an organizational field with the following:

> "the notion of field connotes the existence of a community of organizations that partakes of a common meaning system and whose participants interact more frequently and fatefully with one another than those actors outside of the field (Scott, 1994a, pp207-209)" (Scott, 56, 1995).

In the presence of power and strong complementary relations, those interactions within such a field are based upon a dependent relationship between the organization of power and an extended network of social members with in its organizational field. Organizational power in conjunction with the strength of complementary relations creates more centralized network structures that are increasingly dependent upon the resources of the focal organization. Therefore, expanding the organizational field enables the focal organization to derive enhanced positive network externalities or synergistic gains from a larger network structure. The organization's performance is therefore enhanced and a greater number of network members become under the influence by organizations that hold power. In addition, organizational change within this organizational field is likely to be incremental. Any initiated radical change from either the focal or social network

4 This argument is analogous to arguments found in Kauffman's (1995) autocatalytic set theory where the diversity of system elements positively influences the formation of autocatalytic or self-reinforcing chemical reactions.
5 Incremental and radical change is expressed respectively as shorter and longer horizontal segments of this J curve relationship.

members will face inertial and path dependent forces that arise from the development of network based resource complementarities. However, relative to social network members within this organizational field, the focal organization by virtue of its power is more likely to instigate radical rather than incremental changes. By initiating radical change, a single organization with power and strong complementary relations can create a 'ripple effect' that can cause changes in resource use among organizational field members. This is reflective of the 'sensitive dependent' properties of complex systems in which individual influences can cause highly unstable system behaviour (Marion, 1999; Stacey, 1995).

Strength, Power and Diversity

An organization with diverse resources (D) coupled with strong resource complementarity (external orientation) (S) and organizational power (P), is likely to strengthen tendencies for transitive networks. The presence of all three factors enhances performance and sustainability of network members while also reducing the onset of radical change. In conjunction with the above arguments of strength and power, increasing the organization's diversity of resources amplifies the organization's strength of complementary relations and thus, its field of power. This is because increasing an organization's internal resource diversity increases the potential complementary relations to organizational field members. Thus, as new complementary relations can be formed, this increases the organization's strength of complementary relations. As greater resource diversity creates a greater number of resource dependent relationships, this also increases an organization's power. Therefore, in coupling strength and power with organization diversity, diversity has a reinforcing influence in so far as it extends the number of complementary relations and an organization's power to an expanded organizational field. As a result, such an effect enhances organizational performance through a greater capitalization of externalities with in this expanded network structure. In addition, since organization diversity has an expansionary effect on the organizational field, this increases the number of potential combinations of resources with complementary relations that can generate transitive networks. Since transitive networks exhibit self-reinforcing complementary influences, this provides further performance enhancing effects.

More over, as organizations in complex systems are subject to path dependent / inertial influences (Stacey, 1995), the combined influence of these three (S-P-D) factors yield the onset of 'lock in' behaviours (Arthur, 1989). Such 'lock in behaviour' is determined by the pattern of resources dictated by the transitive network in which due to the closed nature of this network structure, network performance is highly sustainable. This is because network based assets are more difficult to replicate or imitate than those resources protected and controlled by any given firm (Dyer and Singh, 1998) and, thus, the complementary resources with in a transitive network are more likely to generate sustainable performance gains.

Although, the combined influence of S-P-D is expected to generate increased and sustainable performance gains, organizations are less likely to initiate radical changes in behaviour. Due to the stabilizing influence of transitive networks, this allows for the development of path dependence processes in which resources become increasingly co-specialized by members with in the transitive network. This form of inter-asset specificity generates negative feedback tendencies in resisting radical changes. As result, organizational diversity has a reinforcing influence to the strength of complementary relations and

organizational power in so far as creating larger organizational fields that are more resilient to radical change that can be generated with organizational diversity alone.

Power and Diversity

In the presence of power and diversity, the sustainability and performance of organizations is reduced relative to conditions where all three factors (S-P-D) are present. Power and diversity still affords a closed network structure in which performance gains are derived from the complementarities of the transitive network. However, in the presence of limited number of complementary relations (i.e. weak complementary relations), the organization's field of influence is restricted to a smaller membership of network members. As a result, the performance gains from transitive networks are reduced relative to conditions where all three factors are present.

In addition, relative to the presence of strength, power and diversity, radical organizational change is more likely to occur. Organizations with power and diversity face fewer constraints imposed by a larger network structure. Smaller network structures are less 'structurally embedded' than those network structures containing larger memberships. Specifically, in the absence of strong complementary relations, there is a reduced occurrence where changes in organizational resources are incompatible or have conflicting constraints to those resources chosen by members with in a smaller organizational field than network structures containing greater organizational members. The absence of strong complementary relations therefore reduces the occurrence of conflicting constraints, and, therefore provides greater flexibility for organizations to conduct radical change. In addition, with organizational diversity, organizations have greater degrees of freedom to explore complimentary combinations of resources. However, the presence of organizational power has a mitigating effect on the extent of radical organizational change and therefore, even though, organizations have greater flexibility to explore new and complementary resource combinations, the occurrence of radical organizational change is limited[6].

Strength and Diversity

In the presence of strong complementary relations (external) and organizational resource diversity, organizational performance is expected to be highly volatile and organizational change is expected to be radical. Under such conditions, the organizational field consists of a large number of social members where each is directly and indirectly related by the diversity of complementary resources held by network members. In the absence of an ordering influence, such as organizational power, and due to the high interdependence of strong complementary relations, organizations with in this organizational field are continually adjusting their resources so as to search and discover new complementary resource configurations. Organizational diversity and the strength of complementary relations not only increases the space of permitable complementary configurations but also renders the resources choices of network members to be highly interdependent. Since Schumpeterian innovation is a process of novel recombination of resources (Loasby, 1999), radical organizational changes involving search in this greater space of complementary combinations is likely to occur. More over, due to strong complementary relations, such radical organizational change will impact the resources choices of other network

6 Nevertheless, relative to the presence of strength, power and diversity, power and diversity does provide for a greater extent of radical changes initiatives.

members and therefore likely to influence innovative experimentation of other organizations. That is, due to radical organizational changes, new innovations may spur positive feedback influences that motivate further motivations. Innovation researchers characterize this as a sequential innovation process (Scotchmer, 1991). With such radical organizational change, and given that the performance of members with in an organizational field are highly interdependent, one, therefore, expects organizational performance to be highly volatile. This behaviour is consistent with the properties of NKCS fitness landscapes described by Levinthal (1997, 2002) and McKelvey (1999). They argue that high interdependence coupled with system containing a greater number of part leads to chaotic behaviour in which organizational change and performance is highly volatile and sensitive to the behaviours of network members.

Complexity Management Implications and Discussions

The proposed S-P-D framework contributes to management complexity by underscoring not only the complex nature of social interactions but also its implications towards the management of organizational change in increasingly turbulent market environments. One of the challenges expressed by complexity researchers has been the attributed to the conceptual difficulties in understanding the behaviour and performance of a complex system. The proposed S-P-D framework provides an initial step in dimensionalizing the structure of social networks so as to reduce the ambiguity in understanding the complexity of system behaviour. Specifically, the S-P-D framework provides an explicitly socialized view of complex interactions to explain organizational change and performance. It represents a departure from the 'design and mechanistic' approaches of current strategic management thinking (Farjoun, 2002) to embrace the dynamic and spatial influences that impact organizational change development.

More over, the S-P-D framework can be extended to explain and predict patterns of behaviour in complex social systems. With increasingly turbulent competitive market environments, this is of particular importance. For instance, the sensitive dependent nature of chaotic system can occur in conditions of strong resource complementarity and organizational diversity. Chaotic behaviour is manifested in terms of increased volatility in organizational performance and increased occurrence of radical organizational change. While on the other hand, the emergence of order in the form of transitive networks can occur in the presence of strong complementary relations, organizational power and diversity. Both social structures can simultaneously occur to generate 'edge of chaos' behaviours. In that, market systems containing both chaotic and orderly social structures can yield organizational behaviours that consist of incremental and radical organizational changes. Organizations at the 'the edge of chaos' will involve balancing the efficiencies in exploiting complementarities conferred by the ordering influences of S-P-D organizational fields while at the same time incorporating those innovative experimentations conducted by S-D organizational fields.

Another contribution of this research is it explicitly identifies performance with particular social network configurations. Social network theorists (Smelser and Swedberg, 1994) identify this as an area where further research needs to be conducted. Specifically, S-P-D approach provides a framework to consider the performance associated with particular social network structures. Lastly, with respect organizational change research, there is an explicit recognition that organizational context is an important aspect of organizational change processes (Pettigrew

et al, 2001). Organizational context is incorporated through concepts of complementarities and its relation to social network structure.

As a result, from this research, the pattern and structure of complex social interactions can be used to develop testable hypothesis of organizational change and performance. In particular, directions for future research include the application of agent base modelling techniques towards the S-P-D framework. As agent based methods emphasize heterogeneous and non-linear interactions of complex systems, it would provide a useful tool to testing the relationships between the complexity of social interactions and organizational change and performance.

References

Adler, P. S., & Kwon, S. (2002), "Social capital: Prospects for a new concept," *Academy of Management Review*, 27 (1), 17-40.

Arthur, W.B. (1989), "Competing technologies, increasing returns, and lock-in by historical events," *The Economic Journal*, 99 (394), 116-131.

Brown, S and Eisenhardt, K. (1998), *Competing on the Edge: Strategy as Structured Chaos*, Boston, MA: Harvard Business School Press.

Burt, Ronald. (1992), *Structural Holes: The Social Structure of Competition*, Cambridge, MA: Harvard University Press.

Cusumano, Michael, Mylonadis, Yiorgos and Rosenbloom, Richard. (1992), "Strategic Manoeuvring and Mass Market Dynamics: The Triumph of VHS over Beta," Business History Review, 66 (Spring), 51-94.

Dyer, J., & Singh, H. (1998), "The relational view: cooperative strategy and sources of inter-organizational competitive advantage," *Academy of Management Review*, 23(4), 660-679.

Farjoun, Moshe. (2002), "Towards an Organic Perspective on Strategy," *Strategic Management Journal*, 23, 561-594.

Feld, S. (1981), "The Focussed Organization of Social Ties," *American Journal of Sociology*, 86 (5), 1015-1035.

Graff, G.D., Rausser, G.C., & Small, A.A. (2001), *Agricultural biotechnology's complementary intellectual assets*, Working Paper (01-08). Institute for Social and Economic Research and Policy (ISERP).

Jantsch, E. (1980), *The Self-Organizing Universe: Scientific and Human Implications of the Emerging Paradigm of Evolution*, New York: Pergamon Press.

Kauffman, S.A. (1995), *At Home in the Universe: The Search for Laws of Self-Organization and Complexity*, New York: Oxford University Press.

Kalaitzandonakes, N., & Bjornson, B. (1997), "Vertical and horizontal coordination in the agro-biotechnology industry: evidence and implications," *Journal of Agricultural and Applied Economics*, 29 (1), 129-139.

Kraatz, M.S. (1998), "Learning by association? Inter-organizational networks and adaptation to environmental change," *Academy of Management*, 41(6), 621-643.

Lachmann, L. (1947), "Complementarity and Substitution in the Theory of Capital," *Economica*, 14 (54), 108-119.

Lachmann, L. M. (1977), *Capital, Expectations, and the Market Process: Essays on the Theory of the Market Economy*, Kansas City, Kansas: Sheed Andrews and McMeel Publishing.

Levinthal, D. A. (1997), "Adaptation on Rugged Landscapes," *Management Science*, 43 (7) 934-951.

Levinthal, D.A. (2002), "Organizational capabilities in complex worlds," In G. Dosi, R.R. Nelson, & S.G. Winter. (Eds.), *The nature and dynamics of organizational capabilities*, Oxford University Press Inc, USA, 363-381.

Levinthal, D. A. and Warglien, M. (1999), "Landscape: Design for Local Action in Complex Worlds," *Organizational Science*, 10 (3), 342-357.

Lewin, P. (1997), "Capital in Disequilibrium: A re-examination of the capital theory of Ludwig M. Lachmann," *History of Political Economy*, Winter (forthcoming).

Loasby, B. J. (1999), *Knowledge, Institutions and Evolution in Economics: The Graz Schumpeter Lectures*, London: Routledge.

Macintosh, R. and Maclean, D. (1999), "Conditioned Emergence: A Dissipative Structures Approach to Transformation," *Strategic Management Journal*, 20 (4), 297-316.

Mathews, M., White, M. and Long, Rebecca. (1999), "Why Study the Complexity Sciences in the Social Sciences?" *Human Relations*, 52 (4), 439-462.

Matsuyama, K. (1995), "Complementarities and cumulative processes in models of monopolistic competition," *Journal of Economic Literature*, 33 (2), 701-729.

Marion, R. (1999), *The Edge of Organization: Chaos and Complexity Theories of Formal Social Systems*, Thousand Oaks, CA: Sage Publications.

McKelvey, Bill. (1999), "Avoiding Complexity Catastrophe in Co-evolutionary Pockets: Strategies for Rugged Landscapes," *Organizational Science*, 10 (3), 294-321.

Nahapiet, J. & Ghoshal, S. (1998), "Social Capital, Intellectual Capital and the Organizational Advantage," *Academy of Management Review*, 23 (2), 242-266.

Pettigrew, A, Woodman, R. and Cameron, K. (2001), "Studying Organizational Change and Development: Challenges for Future Research," Academy of Management Journal, 44 (4), 697-713.

Pfeffer, J. and Salancik, G. (1978), *The External Control of Organizations: A Resource Dependence Perspective*, New York: Harper & Row.

Powell, W. W., Koput, K.W. and Smith-Doerr, Laurel. (1996), "Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology," *Administrative Science Quarterly*, 41(1), 116-145.

Rosenhead, J. (2001), "Complexity Theory and Management Practice," Human Nature Review. (http://human-nature.com/science-as -culture/rosenhead.html).

Scott, R. W. (1995), *Institutions and Organizations*, Thousand Oaks, CA.: Sage.

Scotchmer, Suzanne. (1991), "Standing on the shoulders of giants: cumulative research and the patent law," *Journal of Economic Perspectives*, 5 (1), 29-41.

Smelser, Neil J. and Swedberg, Richard, (1994), "The sociological perspective on the economy," In Smelser, Neil J. and Swedberg, Richard (Eds.), *The Handbook of Economic Sociology*, Princeton, New Jersey: Princeton University Press, 3-26.

Stacey, R.D. (1995), 'The Science of Complexity: An Alternative Perspective for Strategic Change," *Strategic Management Journal*, 16, 477-495.

Teece, D.J. (2000), *Managing intellectual capital: Organizational, strategic, and policy dimensions*, New York: Oxford University Press.

Teng, Bing-Sheng and Cummings, Jeffrey. (2002),"Trade-offs in Managing Resources and Capabilities," *Academy of Management Executive*, 16 (2), 81-92.

Thompson, James, (1967), *Organizations in Actions: Social Science Bases of Administrative Theory*, New York: Mc Graw Hill.

Whittington, Richard, Pettigrew, Andrew, Peck, Simon, Fenton, Evelyn, Conyon, Martin. (1999), "Change and Complementarities in the New Competitive Landscape: A European Panel Study, 1992-1996," *Organization Science*, 10 (5): 583-600.

Figure 1
J – Curve Relationship Expressed in terms of he S-P-D Framework