

RURAL ECONOMY

**Knowledge Based Competitive Strategies: Strategic
Complementarities from an Austrian Economic and
Strategic Network Perspective**

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Abstract

The concept of knowledge and its related dimensions of information and learning have traditionally received considerable research attention by scholars of organization and strategic management theorists. The increasing role of knowledge as a defining characteristic of the modern knowledge economy has renewed an interest to the importance of knowledge to a firm's competitive advantage. Such interest has raised a significant conceptual issue as to whether the new knowledge economy warrants an alternative framework to understanding competitive strategy. As a result, a conceptual model of knowledge based competitive advantage is proposed. Such a conceptual framework provides a departure from the static perspectives of Resource-based view and Industrial Organizational economic perspectives in accommodating for evolutionary changes of network knowledge. Implicit in this perspective is that sustainable competitive performance is not a realizable outcome. Rather knowledge based competitive performance is transitory in which the extent of such performance is contingent on the management of evolving network relations.

Motivations for a Knowledge Based View

The concept of knowledge and its related dimensions of information and learning have received considerable attention by management scholars (Eisenhardt & Santos, 2002; Nonaka & Teece, 2001; Teece, 2000). Within these concepts of knowledge, there has been a widespread use of knowledge perspectives to investigations of firm organization (Conner & Prahalad, 1996; Kogut & Zander, 1996), knowledge creation and dynamic capabilities (Nonaka, 1994; Nonaka & Teece, 2001; Teece, 2000; Teece, Pisano, & Shuen, 1997), management of intellectual capital (Teece, 2000), and knowledge-based strategies (Decarolis & Deeds, 1999; Grant, 1996). However, in spite of this diversity, knowledge based perspectives have largely been influenced by the Resource-Based view of the firm (Barney, 1991; Eisenhardt & Santos, 2002). According to this dominant view, the control and protection of tacit knowledge, that is most difficult to imitate and relatively immobile, constitutes the basis for a sustainable competitive advantage (Eisenhardt & Santos, 2002; Liebeskind, 1996; McEvily & Chakravarthy, 2002). However, as Eisenhardt and Santos note,

“given the current theoretical perspectives on knowledge, knowledge is not yet a theory of strategy (a theory that links independent variables to a specific conception of firm performance) that goes beyond the insights provided by the resource-based view and the related dynamic capabilities approach. That is, once knowledge is conceptualized as a resource, the thinking becomes a special case of the resource-based view of the firm” (2002:161).

Although knowledge as a resource has a certain appeal, the current approach has not considered that knowledge is intricately tied to the perceptions of the individual mind. Knowledge invariably starts with the engagement of the individual mind (Kirzner, 1997; Mises,

1949; Nonaka, 1994) to which meaning is socially constructed through ongoing social relations. Individual subjectivism raises the problem of the use of knowledge and not merely the economic allocation of scarce resources in society. As Hayek contends,

“it is rather a problem of how to secure the use of resources known to any of the members of society, for ends whose relative importance only these individual knows”(1949: 77-78).

As one's subjective knowledge differs from others, an individual's use of resources for generating sustainable competitive advantages also differs. Subjectivism knowledge is, therefore, a primary contributor to differential performance. This is often described as the nature of entrepreneurship (Jacobson, 1992; Kirzner, 1997). However, entrepreneurial research is often challenged with difficulties in explaining and predicting differential performance from individual attributes alone, such as leadership, charisma, vision, risk taking etc. It renders entrepreneurial research to be rich in description but offers little in determining definitive factors that influence entrepreneurial performance. This research argues differences in entrepreneurial performance can be informed with the concept of complementarities as a source of economic gain. The concept of complementarities underscores synergistic relationships between resources –that include not only physical but also intangibly knowledge assets- in which particular combinations of complementary resources can generate rents greater than the sum of their individual contributions (Adler & Kwon, 2002; Dyer & Singh, 1998; Graff, Rausser, Small, 2001; Levinthal, 2002; Matsuyama, 1995; Rausser, 1999; Teece, 2000). Hence, from a knowledge-based perspective, subjective entrepreneurship and the strategic role of complementarities are informative to a knowledge-based view of competitive strategy.

In particular, given that entrepreneurial knowledge is subjective and, therefore, is imperfect and incomplete, a knowledge based competitive strategy is concerned with the utilization of the subjective experiences of society members so as to devise resources in a manner that capitalize upon complementarities as sources of economic gain. Cast in terms of complementarities, this underscores Hayek's (1949) knowledge problem where the use of knowledge is one of the coordination of subjective knowledge experiences that capitalize upon complementary gains.

As a result, a knowledge-based view of entrepreneurship is advocated to explicitly consider the coordination of complementary resources as a source of competitive advantage. Such a view would draw upon Austrian economics, social network theories and institutional arguments that emphasize the configuration of dyadic / networks as sources of complementary gains. This subjective and complementary view of knowledge based competitive advantage alters the basis of competitive advantage not to be exclusively one on securing and protecting scarce resources where competition is one of zero sum games, but rather to one that is explicitly dynamic involving the creation and diffusion of knowledge that provides for positive sum outcomes (Powell & Smith-Doerr, 1994).

This research is organized into three parts. Drawing upon Austrian economics, the first part consists of a characterization of knowledge in terms of its subjective and public goods dimensions. These dimensions of knowledge provide for the conceptual foundations of knowledge based competitive strategy. In particular, these properties are discussed in the context of Hayek's (Hayek, 1949) knowledge problem, which defines the nature and source of competitive gains from a knowledge-based perspective. From this knowledge problem, a conceptual model of knowledge based competitive advantage is developed that integrates social

network theories of ‘structural embeddedness’ and institutional arguments of socialized conventions within the context of complementary resource choices. This conceptual model will be discussed with reference to the growing ‘life science’ sector, because it highlights some of the underlying knowledge processes described by this conceptual model. Propositions of knowledge based competitive strategy are devised and are extended to entry decisions in dynamic knowledge environments. This is done so as to underscore the endogenous and dynamic aspects of knowledge based competition. The remaining part is a discussion of the applications of this proposed model for future research.

Austrian Economic Foundations for Knowledge Based Strategy

The Subjective and Public Good Nature of Knowledge

Austrian economists have had a long tradition in investigating the nature of knowledge (Hayek, 1949; Lachmann, 1977; O’Driscoll & Rizzo, 1985) and, thus, has particular relevance to current thinking in knowledge based perspectives. Namely, Hayek’s (1949) attention to subjective and social knowledge parallels the current distinctions of ‘tacit and codified knowledge’ (Nonaka & Teece, 2001). Tacit knowledge refers to know-how, knowledge routines, personal experience or knowledge that is not easily transferable, while codified forms of knowledge is readily communicated such as objective facts and information (Nonaka & Teece, 2001). With subjectivism, an individual’s knowledge and perception of the world is fragmented and differs in accordance to one’s experiences and beliefs (Hayek, 1949; Kirzner, 1997). Therefore, subjectivism bears much resemblance to the tacit dimensions of knowledge where individuals ‘know more than they can tell’ (Polanyi, 1962) in so far as such subjective perceptions and knowledge are not readily transferable.

On the other hand, Cilliers comments on the distinction between information as facts or codified forms of knowledge from that of subjective and, thus, tacit dimensions knowledge:

“there are facts that exist independently of the observer of those facts, but the facts do not have meaning written on their faces. Meaning only comes to be in the process or interaction. Knowledge is interpreted data”(2000: 10).

Unlike subjective knowledge, codified knowledge exhibits a public good character and has a direct bearing to the Austrian notion of social rules. Social rules represent the collective and subjective knowledge experiences of failed entrepreneurial experiences (Fleetwood, 1995; Sabooglu & Langlois, 1995). Such failure is a result of subjective “error” (Kirzner, 1997) and, thus, according to Sabooglu and Langlois social rules

“transmit only negative knowledge by indicating what is permissible or, more precisely, what agents should not do. Obedience to these rules is beneficial because they represent accumulated experience and, therefore, help the agents to avoid making the same errors as past generations.” (1995: 13)

In relation to the tacit dimensions of subjective knowledge, social rules are more codified forms of knowledge and, therefore, are more vulnerable to the dimensions of a public good. This is because the social rules of failed experiences constitute a form of institutional convention or norm of conduct (Fleetwood, 1995). In agreement with Institutional theorists, these norms of conduct constitute a “shared definition of reality” exhibiting a “taken for granted quality” (DiMaggio & Powell, 1983). Because these social rules constitute shared definitions of reality, they exhibit public good dimensions of non-rivalry and non-excludability. That is, the diffusion of these institutional rules do not preclude others from using knowledge of failed experiences and nor does its use reduce another’s ability to use such knowledge. Through its public good

character, one of the primary roles of rules is coordinating the diverse knowledge of society (Hayek, 1949). Individuals gain access to this collective knowledge of society so as to render more accurate expectations of the behaviours of others and, thus, afford the coordination of diverse activities in the market (Fleetwood, 1995; Hayek, 1949).

Subjective Foundations of Alertness

Since knowledge is founded upon subjectivism and that its progression arises from an alertness to push back the boundaries of ignorance (Kirzner, 1997; O'Driscoll & Rizzo, 1985), subjectivism as the basis for “alert” (Kirzner, 1997) purposeful action is elaborated. Kirzner (1997) describes “alertness” as a risk-taking attitude involving qualities of “vision, boldness, determination and creativity”. In other words, "alertness" refers to the pursuit of non-equilibrium profit opportunities through an entrepreneur's ability to transcend to different means-ends frameworks by utilizing the diverse knowledge in society (Kirzner, 1997). By drawing upon those means best known to the individual and those characteristics of “vision, boldness, determination and creativity”, new knowledge is introduced for the pursuit of undiscovered profit opportunities (Klein, 1999). As a result of profit opportunities from non-equilibrium markets processes (Hayek, 1949; Kirzner, 1997), the alert entrepreneur is incited to introduce new knowledge that devises alternative means and ends to capitalize on such opportunities. As the introduction of new knowledge introduces new possibilities and opportunities, this drives the further discovery of non-equilibrium opportunities. Hence, in this fashion, the progression of knowledge is, thus, endogenously driven by the pursuits of the alert entrepreneur to which this progressively ‘pushes back the boundaries of ignorance’ in society (Kirzner, 1997). This endogenous and uni-directional progression of knowledge has also been termed as Lachmann's (1977) axiom of time.

Subjective and Tacit Knowledge: Capital Plans

The entrepreneur's subjective and tacit knowledge of means-end relations are manifested by an entrepreneur's "capital plans". A capital plan (Lachmann, 1977; Lewin, 1997) embodies an entrepreneur's subjective choice of heterogeneous resources (Horwitz, 1994) - albeit human or physical resources- employed in the production of output product(s). Hence, a plan is a subjective manifestation of an individual's cognitive schema or mental beliefs of means-end relations (Mises, 1949). An individual's ends are fashioned by an entrepreneur's subjective expectation of yet undiscovered profitable opportunities. While, the means chosen to pursue these aims are reflected by an entrepreneur's subjective choice of resources. In this fashion, subjective knowledge is fundamentally embodied in physical capital (Grant, 1996; Lachmann, 1977) where physical capital is largely the articulated aspects one's underlying tacit / subjective knowledge.

Plans and the Concept of Complementarity

As plans are driven by an entrepreneur's subjective knowledge, this imparts heterogeneity to one's plan and has a considerable bearing to the concept of complementarity. A distinguishing aspect of a capital plan is the heterogeneity in the 'use' of resources and how the 'use' of these resources imparts unique complementary relationships with other resources (Lachmann, 1977; Lewin, 1997). That is to say, resource heterogeneity is not defined with respect to its physical attributes, but rather in its function or use (Lewin, 1997). Subjectivity impinges on this heterogeneous attribute of resources in so far as two of the same physical resources can have different uses or functions and, therefore, privy to subjective interpretation (Horowitz, 1994). An implication that follows from this heterogeneous characterization of resources is the presence of complementarities (Lachmann, 1977; Lewin, 1997).

Complementarities are described under numerous terms such as the positive cross marginal productivity of capital (Graff et al, 2001; Lewin, 1997), synergies or complementary resource endowments¹ (Dyer & Singh, 1998), complimentary assets (Teece, 2000), complementary capabilities (Adler & Kwon, 2002). Since the manner at which how resources are used differ from among subjective individuals, it then follows that how such resources are combined to exploit such complementarities are also subjectively influenced (Horowitz, 1994). Hence, a capital plan consisting of combinations of resources is an embodiment of subjective knowledge in regards to its use.

Factor and Structural Complements.

To elaborate on the different types of complementarities, they span different levels of aggregation. One level of aggregation includes complementarities between factor resources within a plan termed as “factor complements” (Lachmann, 1977). Factor inputs are complementary so long as the combined resources serve the desired ends of the entrepreneur (Lachmann, 1977). For example, in the life science sector, complementarities in intellectual assets on plant genetic transformation techniques, and elite crop germplasm (Graff et al, 2001). Alternatively, complementarities can be expressed between business units of a firm such as the crop and seed business of the biotech firm, Syngenta.

Another level of aggregation stems from the complementary relations between the different capital plans termed as “structural complementarity” (Lachmann, 1977). For example, an alliance was formed between Monsanto and Genentech in 1979 to draw upon complementarities from Genentech’s research in bovine and porcine animal growth hormone and

¹ Dyer and Singh (1998) define complementary resources as “distinctive resource endowments of alliance partners that collectively generate greater rents than the sum of those obtained from the individual endowments of each partner” (Dyer & Singh, 666, 1998)

Monsanto's ability to produce large-scale amounts of this growth hormone (Leonard-Barton & Pisano, 1993). Another example of structural complementarities is found in joint ventures or collaborate arrangements where complementarities are found in the innovations of small biotech start-up R&D firms and the manufacturing, financial and marketing capabilities of larger life science businesses (Kalaitzandonakes & Bjornson, 1997). Structural complementarities, therefore, confer sources of inter-organizational rents (Dyer & Singh, 1998). However, the difficulty raised with the capitalization of structural complementarities and even factor complementarities is the alert entrepreneur's task of deducing complementary resource combinations is an enormously demanding cognitive activity. Matsuyama notes,

“in reality, one has to overcome enormous information problems. The set of all products, both existing and potential is huge. Products are not generally symmetric. One has to find out which combinations of products is complementary, and the number of possible combinations grows exponentially with the number of products...and yet new ways of doing business are introduced year after year suggests that a large number of coordination problems are awaiting to be discovered”(1995: 724).

And as Levinthal further comments,

“the presence of significant complementarities makes the problem of intelligent action one which is highly combinatorial. The appropriateness, or put more tersely, the pay-off of a given behaviour depends on a wide set of other actions with in the organization and, indeed, actions external to the organization as well” (2002: 363).

Therefore, in the presence of structural complementarities, the entrepreneur's problem is concerned with the configuration of resources of a plan that capitalize on structurally complementary gains. This configuration of resources in turn has a direct bearing on the choice of factor complements. Thus, the capitalization of structural complement consists of devising plans that are not only structurally complementary to the plans of others, but also consists of resource combinations that are factor complements. In lieu of the cognitive demands imposed by the combinatory nature of complements, this configuration of resources/plans defines the competitive basis for a knowledge based view of entrepreneurship and follows from Lachmann's theory of capital structure where markets have a tendency to favour 'complementary' plans than those that do not (Lachmann, 1977).²

Complementarities and Knowledge Based Advantage.

Given complementarities, wealth creation is not exclusive to the internal resources of the firm –as depicted by the Resource-Based view- but is found in the configuration of resources that are complementary³ –factor and structurally- to other social members (i.e. other entrepreneurs). This coordination of resources to harness structural complementarities is a source of inter-organizational rent that is idiosyncratic to the resource / plan choices of social members. This results 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 & Singh, 667, 1998). Specifically, social members' resource/ plan choices dictates the pattern of complementarities to an individual entrepreneur and, thus, determines the entrepreneur's space

² However, Lachmann (1977) has not contended with the cognitive difficulties -as imparted by subjectivism- in devising complementary resource configurations.

³ For generality, complementarities refer to both factor and structural complements in which both are intertwined concepts.

of knowledge opportunities. Competitive advantage is, therefore, the discovery of those undiscovered complementary relations in a market (Graff et al, 2001; Levinthal, 2002; Teece, 2000). The entrepreneur's "alert" ability to exploit the complementary relations also solves Hayek's (1949) knowledge problem of coordinating the diverse knowledge experiences in the market.

Structural Embeddedness and the Complementary of Plan Choices

Since an entrepreneur's knowledge based competitive advantage resides in the discovery of complementarities across different levels of aggregation (i.e. factor and structural complements), these knowledge opportunities are "structurally embedded" (Granovetter, 1985) by the plan choices of social network members. Structural embeddedness refers to the notion that social network relations constrain as well as provide for opportunities to individual action (Granovetter, 1985; Gulati, Nohria, & Zaheer, 2000; Powell & Smith-Doerr, 1994). Social network relations can be viewed as form of "social capital" (Adler & Kwon, 2002; Coleman, 1988) or social resource to which an individual's domain of action is enlarged or constrained through the access of this social capital (Adler & Kwon, 2002; Coleman, 1988; Gulati et al. 2000; Powell & Smith-Doerr, 1994). An individual's plan choices are, therefore, constrained or expanded in a structurally embedded manner by the pattern of complementary relations imparted by the plan choices of network members.

However, due to one's subjectivity, these social network relations are asymmetrically defined by the entrepreneur's subjective knowledge of complementary relations. Each

entrepreneur, therefore, has a different⁴ social network. Social networks are egocentric.

According to Porac, Paton, Konfer, this conveys a social construction logic where

“market structures are constraints only because managers believe they exist rather than being an exogenous force acting on managerial minds. Market structure is an endogenous product of the managerial mind. While markets are arenas for economic transactions, at their core are routinized thought patterns and interlocked networks of managerial attention”(1995: 224).

Stated alternatively, subjectivism imparts an egocentric view of social networks whose social capital is defined by complementary network relations. Since knowledge processes are endogenously driven by the subjective and alert pursuits of the entrepreneur (Fleetwood, 1995; Hayek, 1949; O’Driscoll & Rizzo, 1985), this social capital is to an extent constructible and, therefore, provides room for strategic intent. Alert entrepreneurs, through innovative acts, can introduce novel plans that alter or introduce new complementary relations not found previously. Through the purposeful actions of alert entrepreneurship, the knowledge opportunities found among one’s social network of complementary relations are, therefore, constructible. However, it is limitedly so, as this social capital is also co-determined by the subjective actions of others (O’Driscoll & Rizzo, 1985) and as the actions of other entrepreneurs actions cannot be perfectly known due to subjectivism (Hayek, 1949; O’Driscoll & Rizzo, 1985), the construction of this social capital limits the extent of coordination necessary for capitalization of complementary relations. Thus, non-equilibrium opportunities arise from these coordination possibilities.

⁴ Such difference is a matter of degree that is influenced by the extent of differences in tacit knowledge among entrepreneurs

Subjective View of Social Networks.

In motivating this subjective view of social networks, the network structure of complementary relations is not determined by objective or exogenous technological criteria, but rather is an endogenous outcome of the subjective perceptions and actions of the alert entrepreneur. This is not to say, objective technical criteria are unimportant to the selection of complementary resource configurations. But with ‘casual ambiguity’ (Lippman & Rumelt, 1982), environmental complexity, personal experiences/ biases, and complex endogenous changes in the pattern of complementary relations (Ng, 2001), an entrepreneur can not reliably discern the technical criteria of complementary resource configurations and, therefore, the subjective perception of complementary relations are guiding forces to entrepreneurial action. A case in point is the failure to realize synergies of the life science strategy from pharmaceutical and agri-chemical businesses, for such firms as Aventis and Novartis (Thayer, 2001). Alternative ‘life science strategies’ are being pursued that focus on leveraging synergies from core pharmaceutical business and divestitures of agribusiness units in seed, crop and chemical divisions. For example, Novartis and AstraZeneca divested its agribusinesses in crop and seed protection to form Syngenta so as to concentrate on these synergies but while also separating it from its pharmaceutical businesses (Thayer, 2001). These re-orientations in ‘life science’ strategies highlight the potentially subjective nature in the assessment of complementary relations.

Due to subjectivism, the implication of the asymmetric nature of social networks is it extends the search space of knowledge experience beyond one’s local network. This reason for this is due to the bounded rationality imposed by subjectivism, an entrepreneur draws upon a diversity of entrepreneurial knowledge in its local network. This extends an entrepreneur’s

knowledge beyond its local network to knowledge of complementary relation in other social networks. This co-determinacy of knowledge experiences utilizes the diverse knowledge in society and is a solution to Hayek's (1949) knowledge problem in so far as entrepreneurs are utilizing the knowledge of egocentric social networks to devise complementary resource configurations. However, in order to gain access to the knowledge of one's social network, the social network concepts of strong and weak information ties become of importance in capitalizing these complementary relations.

Strong Information Ties

From social network theories, the notion of strong and weak information ties recognizes the premise that 'whom' one is connected to determines the uniqueness of information transmissions (Burt, 1992; Granovetter, 1973, 1985; Kraatz, 1998; McPherson & Ranger-Moore, 1991). Strong ties contain those information connections among similar knowledge individuals, and, therefore, information transmission is largely redundant (Adler & Kwon, 2002; Burt, 1992; Granovetter, 1973; 1985; Kraatz, 1998). As Kraatz notes,

“strong ties are also less likely to provide novel information or insights because actors are much more likely to form strong ties with socially similar actors, who tend to possess the same information and to hold similar opinions” (1998: 623).

Strong information ties reduces uncertainty by promoting in depth exchanges of knowledge and adaptive imitations to environmental threats (Kraatz, 1998). Since strong information ties are made between similar knowledge individuals, the formation of these ties tend to form homophilic groups; groups consisting of self-similar individuals with in a closed network share common experiences (Adler & Kwon, 2002; Burt, 1992; Kraatz, 1998; McPherson & Ranger-Moore, 1991; Nonaka, 1994; Porac et al, 1995).

Homophillic processes occur to reduce the complexity or diversity of social interactions and, thus, it economizes on the cognitive abilities of the individuals (McPherson & Ranger-Moore, 1991).

Homophillic formations occur as a result of entrepreneurs' incentives to form strong information ties to economize on the cognitive cost in devising factor complements. Specifically, the formation of strong information ties to entrepreneurs with similar plan choices reduces, but not eradicates the uncertainty or 'ambiguity' (Lippman & Rumelt, 1982) in factor complementary choices. Strong information ties provides for the identification of comparable business practices so as to isolate a competitive arena to which weaknesses and strengths can be identified. It provides for the identification of not only one's rivalry but also a means to differentiate with in a homophillic group an entrepreneur's choices of factor complements. Such a view agrees with Porac et al's social construction of imperfectly competitive markets where they note

“following White (1981), we view an imperfectly competitive market as a socially constructed network containing clique-like subgroups of firms that define each other as competitors and monitor each other's actions”(1995: 204).

However, the distinction resides in the explicit attention to factor complements as a source of competitive differentiation with in an imperfectly competitive market. Given subjectivism, the notion of a homophillic group is cast in terms of the imperfect competition for factor complements.

Social Rules as a Public Good and Strong Information Ties in Homophillic Groups

With this characterization of imperfect competition with in a homophillic group and in drawing upon the public good nature of social rules, strong information ties serve in the

transmission of social rules of a homophilic group so as to minimize the search cost of seeking factor complements. This is because the redundancy in information connections among similar knowledge entrepreneurs contributes to the sharing of tacit knowledge (Nonaka, 1994) to breed conformity to social rules (i.e. social consensus) through adaptive imitative responses (Adler & Kwon, 2002; Coleman, 1988; Kraatz, 1998). Through the institutional processes of mimetic isomorphism (DiMaggio & Powell, 1983), this results in the establishment of social rules or norms of legitimized factor complementary resources. However, unlike the institutional logic of DiMaggio & Powell (1983), the mimetic process does not inevitably yield the homogeneous behaviours. This is because imitation is privy to the subjective interpretations of factor complements.

The public dimension of social rules becomes important to the diffusion of the knowledge of factor complements within such homophilic groups. As alert entrepreneurs have subjective and therefore imperfect knowledge of factor complements, entrepreneurs draw on social rules to create new patterns of mental associations in formulating alternative resource combinations. Specifically, social rules as a public good of failed capital plan experiences entails those resource combinations that do not exhibit factor complements. For example, the failure of the 'life science strategy' of the 1990's in realizing synergies between pharmaceutical and agribusiness activities among life science firms such as Aventis and Novartis (Thayer, 2001) constitutes a social rule as it reflects failed combinations of factor complements in their pharmaceutical and agribusiness activities. Hence, following from institutional legitimacy logic, the conformance to social rules through strong information ties guides an entrepreneur's action by constraining their choice of factor resource use. This economizes on "search costs" (Cyert & March, 1963) as it reduces the cost of untried conventions (Scott, 1995). Therefore, increasing

the number of strong information connections is a source of increasing knowledge based competitive advantage because it serves to remove those resource combinations that do not exploit factor complementary opportunities. Given the tremendous resource requirements for R&D investments in life science industries, the abeyance to these social rules can constitute a very significant savings in maladaptive investments in research. With increases in the densities of these strong information ties, the greater diffusion of social rules increasingly bounds the space of factor complementary choices to yield a social consensus of legitimized factor resource choice.

However, this performance-enhancing aspect of strong information ties does not hold at greater densities. Increasing the density of strong information ties imparts further redundancy in knowledge to which 'lock in' or 'band wagon' path dependent behaviours can arise (Arthur, 1989; Poudier & St. John, 1996). Lock in effects arises because the interdependence of knowledge experiences collectively constrains the experience of the individual. This follows from Poudier and St. John's argument that "collective strategic myopia" constrains strategic choice to innovate (1996: 1208) and with institutional perspectives (DiMaggio & Powell, 1983; Scott, 1995) the diffusion of institutional rules results in increasingly legitimized and thus inert behaviours⁵ (Powell & Smith-Doerr, 1994).

These path dependent processes are a detriment to an entrepreneur's knowledge based advantage. Knowledge based opportunities continually evolve from the alert pursuits of entrepreneurs to formulate complementary plan choices. As new plans are formulated, especially plans in a different knowledge space such as a different homophilic group, new complementary

⁵ Due to subjectivism, individual behaviours are not unilaterally determined by institutional behaviours and, thus, alert entrepreneurs can still exert voluntaristic behaviours with in an institutional setting.

relations (i.e. factor and structural complementarities) are formed to an existing homophilic group. As a result, path dependent processes prohibit entrepreneurs from being able to capitalize on complementarities arising from the changing plan structure of society (Ng, 2001). Therefore, at extensive densities of strong information ties, this precludes entrepreneurs from being able to respond to complementary gains from the changing pattern of plans external to its homophilic group.

In addition, since the diffusion of social rules reduces the asymmetry or egocentricity of knowledge experiences in a homophilic group, this renders increasingly competitive circumstances where depressed prices and improvements in costs reductions become increasingly marginal because the shared consensus of factor complements become a standard industry practice. This is in agreement with arguments posed by Institutional theorists (DiMaggio & Powell, 1983; Scott, 1995; Rauser, 1999) where increasingly codified knowledge results in increasing competition. Hence, the increasing diffusion of social rules results in the diffusion of rents that arise from differentiated factor resource uses. These forces lead to increasing renditions of the mature stages of an entrepreneur's product life cycle (Teece, 2000). As a result, given these contrary of forces, the following is proposed:

Proposition 1: Within a homophilic group, the potential for revealing factor complements and thus knowledge based competitive advantage is a non-monotonic / inverted U shaped function of the density of strong /redundant information ties.

Timing of Entry in Complementary Environments

By explicitly considering the role of complementarities, one of the implications of proposition 1 is it augments research on timing of entry. Timing of entry is often discussed in terms of leader and follower distinctions (Lieberman & Montgomery, 1988, 1998). Leaders

exhibit first mover advantages from gains to early market access arising from technological leadership and/or learning curve related experiences (Lieberman & Montgomery, 1988, 1998). However, evidence has indicated first mover gains are largely appropriated by second movers (Lieberman & Montgomery, 1998; Teece, 2000).

Consistent with the logic of proposition 1, in the presence of complementarities, knowledge based competitive advantages accrue more to second movers than first movers. Although the first mover may be the original inventor of an innovation, the success of technical innovation, especially in biotechnology industries (Graff et al, 2001; Rausser, 1999), rests upon other complementary resources relating to its commercialisation (i.e. manufacturing, distributions, marketing etc) (Teece, 2000; Rausser, 1999). Hence, in spite of resource advantages conferred by early entrants, first movers can acquire the wrong sets of complementary resources due to uncertainties in the market. As Lieberman and Montgomery note,

“Early entry into an emerging market may facilitate such accumulations [superior resources and capabilities]. But pioneers often miss the best opportunities, which are obscured by technological and market uncertainties. In effect, early entrants may acquire the ‘wrong’ resources, which prove to be of limited value as the market evolve” (1998: 1112).

That is, Teece (2000) argues failures of first movers to appropriate first mover gains arises from the entrepreneur’s inability to control complementary assets to one’s technological competence. Therefore, early entrance in the presence of uncertainties in factor complementary use can result in acquiring the wrong combinations of resources necessary for the success of an underlying technology.

This can be recast in terms expressed by proposition 1. In that, the density of information ties can be measured in terms of population densities of a given aggregate group (Mayhew & Levinger, 1976). Hence, one can conceptualise first and 2nd mover entrance in strong information density terms. Specifically, first movers can be viewed as entrance into homophilic groups with an absence of competitive rivalry in which this is equivalent to the absence of strong information connections. On the other hand, 2nd movers are characterized by entrance into homophilic groups with moderate densities of strong information tie connections. 2nd mover entrance confer a knowledge based advantage from entrance in conditions where strong information tie densities exhibit positive influences, such as found in the upward sloping portion of the inverted U shaped density function of proposition 1. Specifically, second movers obtain greater benefit than first movers because their ability to revise in a trial and error fashion and through the assistance of social rules devise those resources that are factor complements to a core technology competence⁶. As the successful commercialisation of a technological innovation requires other complementary resources (Teece, 2000), 2nd movers as oppose to first movers are able to draw upon the social rules of its network members so as to devise resource configurations suited to the underlying technological competence. Hence, gains to second movers are a result of a ‘knowledge spill over effects’ in which the emergence of social rules from previous failed plan experiences (i.e. first movers) guides in the trial and error formulation of more suitable configurations of factor complements. Therefore a ‘wait and see’ approach confers potentially greater benefits to 2nd movers, as 2nd movers are able to utilize the past experiences of early

⁶ Issues of hold-up and opportunism with complementary assets are of particular relevance to the management of intellectual capital. For a further discussion of these issues see (Teece, 2000; Kalaitzandonakes & Bjornson, 1997).

innovators. Hence, these benefits are likely to accrue to 2nd movers in circumstances where technologies require ‘bundles of complementary assets’ and are highly uncertain.

For instance, with the relatively recent advances in the biotechnology of food and agricultural production, technological uncertainties occur from the rapidly changing knowledge base of genetic engineering where recombinant DNA techniques, and DNA sequencing pose considerable sources of technological uncertainty. Amidst such rapid changes, life science firms face considerable challenges in the development of their technological competence in the application of trans genetic techniques while also contending with the uncertainties to consumer acceptance for GM products in European markets. With such uncertainty, this confounds the ability of such firms to choose the correct ‘resources’ that yield complementary resource configurations such as complementary ‘commercialising’ assets in manufacturing, distribution and marketing. These assets have been increasingly recognized as important consideration in the commercialisation of agri-food biotechnological developments (Kalaitzandonakes & Bjornson, 1997). Second movers, especially those that are able to provide improvements to previous biotechnological competence or through the use of more suitable commercialisation assets are able to benefit relative to first mover (i.e. original innovator) because they are able to learn from previous experiences (i.e. social rules). As a result, 2nd movers who enter markets (i.e. a homophilic group) where population densities (i.e. a proxy for the density of strong information ties) are increasing –such as found in the upward sloping portion of proposition 1- can gain a competitive advantage in its use of factor complement resource. A subsequent proposition based on these preceding arguments follows:

Proposition 2: The greater the degree at which an entrepreneur's core technology is dependent upon other factor complements and the greater the degree of market uncertainty, the greater gains are afforded to 2nd movers (follower) who control these factor complements.

Weak Information Ties

Unlike strong ties that diffuse the social rules of factor complements within a homophillic group, weak information ties capitalize upon the “structurally complementary” relations for plans found in different homophillic groups (Ng, 2001). Weak information ties are “bridging” ties that connect entrepreneurs to different homophillic groups and, thus, transmit knowledge of novel content (Adler & Kwon, 2002; Burt, 1992; Granovetter, 1973; Kraatz, 1998; Powell & Smith-Doerr, 1994). These “bridging ties” provides access to structurally complementary relations that arise from the outputs produced by the plans of different homophillic groups. In addition, weak information ties can also provides access to the social rules of factors complements in each homophillic group. However, principally, the function of weak ties, as oppose to strong ties, is to extend the “search” space of complementary relations to include structural complements. An example of structural complements would be synergies in business activities in crop, seed and chemical divisions across life science firms.

In the discovery of these structural complementary relations as sources of economic gain, the diffusion of social rules of factor complements with in each homophillic groups assists the function of weak information in the discovery these complementary gains. Since homophillic groups are comprised of increasingly homogenous plan choices⁷, the plan choices of each homophillic group create increasing delineations of structural complements for plans of other homophillic groups. Hence, through the diffusion of social rules from strong information ties, the

⁷ This is due to the diffusion of social rules of factor complements described by proposition 1.

social rules of factor complements of a homophilic group create legitimized plans, such as industry standards. These legitimized plans become accessed through weak information ties so as to reveal structurally complementary relations between plans of homophilic groups.

Exploration. The discovery of these structurally complementary relations resides in two principal advantages of weak information ties; these advantages stem from “exploration and exploitation” (Levitt & March, 1993). With respect to “exploration”, weak information ties enable the entrepreneur to be responsive to the changing pattern of structurally complementary plan relationships. As the pattern of structural complementary relations are structurally embedded by the plan choices of social network members, weak information ties to different homophilic groups delineate the pattern of structural complementary relations in an entrepreneur's surrounding network. This reduces the space of structural complementary “explorations” and, therefore, reduces the search costs of devising structurally complementary plans. In addition due to the endogenous progression of knowledge, these weak information ties provide adaptation to the changing structural complementarities in an entrepreneur's network. Entrepreneur's are better able to adapt to the changing social network because weak information ties gains access to a diversity of knowledge experiences such that its novel recombination propels the creative discovery of new plans (Powell & Smith-Doerr, 1994) that exploit existing and or new structural complementarities. Specifically, since Schumpeterian innovation is an endogenous and recombinatory process (Loasby, 1999), weak ties recombine the diverse knowledge in one's social network so as to generate innovative plans to which these plans may exploit existing structural complements or introduce new structural complements to other homophilic groups. With such advantages afforded from “explorations”, the density of weak

information ties should be positively related to an entrepreneur's knowledge based competitive advantage.

These advantages are, however, confined to lower densities of weak information tie connections. Under higher densities of weak information ties connections, an entrepreneur's knowledge based competitive advantage is expected to decline. The reason being that continued increases in the density of weak information ties render entrepreneurs to be subjected to increasingly conflicting demands from constituent network members. An individual's dyadic complementary relations with one set of homophilic group(s) become increasingly incompatible to the complementary relations of another – in structural and also factor complementary respects. This follows directly from the structural embedded orientation of entrepreneurial action. The space of structural complementary relations as imparted by the plan choices of social network members serves as not only a source of opportunity to reconfigure plans that exploit this social capital but can also be a constraint. As weak information tie densities increase, an individual entrepreneur can no longer effectively exploit simultaneous complementary opportunities within an increasingly diverse network structure (Levinthal, 2002). This detracts an entrepreneur's from drawing upon their unique experiences in capitalizing on plans with the greatest synergy.

Therefore, one proposes:

Proposition 3: The potential gains afforded from structural complements as a form of knowledge based competitive advantage are a non-monotonic / inverted U shaped function of the density of weak information ties formed.

Exploitation. Another advantage of weak information ties resides in the “exploitation” of ‘network externalities’ of structurally complementary plans. Due to structural complementarities, the greater adoption of a complementary plan increases the value of related complementary plans

in a self-reinforcing fashion. This self-reinforcing behaviour is termed by Matsuyama (1995) as a ‘cumulative complementary process’. This self-reinforcing behaviour is also subject to “increasing returns to scale effects” where the adoption of a technological innovation generates its further adoption to form an eventual industry standard (Arthur, 1989). Therefore, with the presence of structural complements, increasing the population of entrepreneurs with a plan that is structurally complementary to another population can yield “increasing returns to scale effects” (Arthur, 1989). For instance, complementarities between Monsanto’s Roundup Ready® crops (i.e. glyphosate tolerant) and its resistance to Roundup Ready® herbicide (i.e. glyphosate) can yield cumulative complementarities to which increasing returns to scale effects lead to the eventual adoption of Roundup products as a standard among grain producers. During the period between 1995-2001, sales of Monsanto Roundup Ready® herbicide have tripled and constitutes over 80% of the world market for glyphosate to which this growth is attributed to Monsanto’s introduction of Roundup Ready ® crops (Monsanto 2001 annual report). Since populations are depicted in terms of homophillic groups, one can propose,

Proposition 4: For a given density of weak information ties, an entrepreneur’s knowledge based competitive advantage as defined by its ability to exploit structurally complementary relations is positively related to number of structurally complementary homophillic groups and the populations with in such groups.

Like strong ties, this proposition has applications to the timing of entry into markets. Following from the arguments of proposition 2, the likelihood of 2nd mover entrance into a structurally complementary homophillic group –one whose plans are a structural complement to another homophillic group(s)- is conditional on the extent of social rule diffusion in these latter group(s). In particular, through the increasing diffusion of social rules with in homophillic

group(s), the plans chosen by the set of homophilic groups bounds and stabilizes the pattern of structurally complementary relations. This bounded and stabilizing state relieves the entrepreneur's cognitive demands to focus on those resource configurations dictated by these structurally complementary homophilic groups. As a result, entrepreneurs are more likely to enter homophilic groups that are structurally complementary to groups where their social rules are extensively diffused (i.e. under conditions of high densities of strong information tie conditions). Consequently, entrepreneurs are more likely to be 2nd movers rather than first mover entrance when structurally complementary homophilic groups are present. This is because a 2nd mover entrance strategy attains benefits from drawing upon the homophilic group(s)'s social rules to which the guidance influences of these rules aid the formulation of plans that are structurally complementary to these groups. In addition, since structural complementarities exhibit network externality influences that are positively related to the populations of structurally complementary homophilic groups which in turn positively influences social rule diffusion, increasing this population provides a further incentive for a 2nd mover strategy because this increasing populations serves to create cumulative complementary benefits. Given these arguments, one proposes the following proposition:

Proposition 5: The likelihood of entrance by 2nd mover into an emerging homophilic group is positively related to the population of related structurally complementary homophilic groups

The Confluence of Strong and Weak Information Ties

As an entrepreneur's knowledge based competitive advantage resides in the discovery of factor and structural complements, both strong and weak information ties mutually reinforce the entrepreneur's competitive position. These ties jointly define and expand an entrepreneur's

knowledge of the changing complementary relations in the market⁸. These ties alleviate the cognitive demands of the subjective entrepreneur in so far as devising those resources and plans that exhibit factor and structural complements. Strong information ties directly contribute to internalising social rules so as to guide the formulation of factor complements within a homophilic group. While weak information ties facilitate the recombination of diverse knowledge in creating plans that exploit as well as explore structural complementary relations between homophilic groups. Hence, alert entrepreneurship is reflected by the entrepreneur's ability to employ the mutually reinforcing influences of strong and weak information ties. Given the mutually supportive efforts of both strong and weak information ties, one proposes.

Proposition 6a: For a given density of strong information ties and weak information ties, their combined effects have a mutually supportive or cumulative effect on an entrepreneur's knowledge based competitive advantage.

Also in drawing on proposition 5,

Proposition 6b: For a given combined density of strong and weak information ties, increasing the population of homophilic groups with complementary plans has a positive effect on an entrepreneur's knowledge based competitive advantage.

Conclusions: Implications for Application

This research's knowledge based view of strategy has raised a significant conceptual issue as to whether the increasing attention to knowledge driven markets warrant an alternative framework to understanding competitive strategy. A conceptual framework of knowledge based competitive advantage has been proposed. Knowledge based competitive advantage rests upon the inseparability of human knowledge from individual subjectivism where the explicit economic

⁸ Complementary relations will continually change due to Lachmann's axiom of the arrow of time.

problem and thus basis of knowledge advantage resides in the coordination of complementary resource configurations. More formally, knowledge based competitive advantage is the dynamic configuration of resource / plan choices to the changing knowledge in one's social network. This involves the exploitation of complementarities found within resources of a plan (factor complementarities) and between plans (structural complementarities). The contribution of this research is it provides a departure from the internal and static pre-occupation of resource-based perspectives to accommodate for evolutionary changes of network knowledge. Implicit in this perspective is that sustainable competitive performance is not a realizable outcome. Rather knowledge based competitive performance is transitory in which the extent of such performance is contingent on the management of evolving network relations.

This approach can be extended to the growing interest in supply chain networks (Lazzarini, Chaddad, & Cook, 2001). Although the conceptual model of knowledge based competitive advantage is largely oriented to horizontal complementary relations (factor and structural complements), it does not preclude vertical complementary relations between stages of a supply chain. As a result, one of the potential applications for this conceptual model is it can be employed within a supply chain network framework (Lazzarini et al, 2001) to examine structural changes or "punctuated equilibrium" (Gersick, 1991) changes in agri-food markets. For instance, North American and European food markets have witnessed significant transitions from a commodity orientation of food production and consumption (i.e. emphasis placed on cost efficiencies and homogenous food product attributes) towards increasingly heterogeneous or differentiated food demands that employ increasingly specialized productive and organizational (i.e. vertical coordination) resources (Boehlje, 1996; Ng, 2001; Rausser, 1999). These include developments in information technology in food retailing (i.e. efficient consumer response ECR),

improvements in seed, plant (i.e. cold tolerance wheat), livestock genetics (i.e. improvements in nutrition conversion) from advances in biotechnology, increasing brand differentiation along food quality attribute dimensions (i.e. brand equity), identify preserved channel systems, etc. The extent of the heterogeneity of such resources impacts the space of complementary relations (factor and structural complements) within such a supply chain system environment.

Entrepreneurship is, thus, a process of exploiting such complementarities in food supply systems within and between stages to produce products and services. This, however, is a departure from the common rhetoric that consumer sovereignty is the pivotal force of the modern face of agriculture (Boehlje, 1996). Rather, a tempered view is offered to recognize that complementary influences endogenously shape the changing face of modern food systems. The implication of this view is that since the incentives a supply chain are endogenously determined by the pattern of complementary relations, structural changes in agri-food markets are not entirely unpredictable phenomenon to exogenous changes in food consumer desires.

In addition, this research's model of knowledge based competitive advantage has also potential applications to the study of innovations in creating structural change or 'punctuated equilibria' (Gersick, 1991). The direction of innovation can be boundedly determined by the space of complementarities in the system in which the study of innovation diffusion, such as the adoption of an industry standard, can be examined. According to the proposed framework, the successful commercialisation of an innovation and its subsequent formation as an industry standard is directly related to the extent to which initial technology exhibits the greatest interdependency or complementarity (horizontal and vertical) to resources used downstream or upstream in a system. As a result, the successful development of multiple technologies and the resulting formation of an industry standard can be determined apriori by assessing the extent to

which the core technology exhibits complementarities with in and between stages of a supply chain system (i.e. application of proposition 2). As a result, this conceptual framework lends potential application for future research investigations in which the measurement of complementarities would be an integral component for testing the propositions of this research.

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