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Innovation – The Case for Multi-Level Research

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INNOVATION - THE CASE FOR MULTI-LEVEL RESEARCH

It is now generally recognised that we are in the midst of major economic upheaval, with the kind of ramifications not seen since the industrial revolution of the early nineteenth century. Products of the human mind, such as software, pharmaceuticals and microprocessors, are replacing those of the earth and the blast furnace as our primary measure of economic power, and information technology is set to become the world's biggest industry within the next decade, displacing the automobile as the primary barometer of economic activity (Mandel 1997). As a recent editorial in Forbes has pointed out, in an international economy built on new technologies that are free from many physical restraints change "goes into overdrive" (Forbes 1997, p.130).

It is no surprise, then, that innovation is fast becoming the central preoccupation in management and related studies. "Innovate or fall behind: the competitive imperative for virtually all businesses today is that simple", is how Leonard and Straus (1997, p.111) see it, and their view is widely shared (Peters 1990, Beck 1992). Yet, in spite of this increasing attention, we still have much to learn about the process of innovation in organisational and institutional settings. Questions such as why some firms are more innovative than others in the same industry, why some regions or countries are more innovative in certain industry sectors than others, and why innovation of the more radical kind most often tends to come from outside of existing industries are still being pursued with little resolution in sight.

To date, most studies of innovation and its link with competitiveness have tended to focus on a single level of analysis. Industrial economists, evolutionary economists and institutional theorists have all tended to focus on the nature of innovation at sectoral, regional/national or even global levels (Nelson 1992, Jacobson 1994, Niosi and Bellon 1996), while management theorists have tended to focus on factors governing innovation at the level of the firm (Quinn 1985, Sinetar 1985, Drucker 1986, Kanter 1988, Cohen and Levinthal 1990, Leavy 1997). This paper argues that the time is now ripe for a move towards more multi-level, interdisciplinary research. The early part of the paper reviews the literature on innovation and finds thematic and conceptual convergence across levels and disciplines around the relationship between innovative activity and institutional context and the nature of the innovation process itself. This convergence, the paper concludes, indicates the opportunity for multi-level, interdisciplinary research and points the way towards the kind of framework based on

systems thinking, learning theory and dynamic analysis, through which such research might be pursued.

THE INSTITUTIONAL CONTEXT FOR INNOVATION

Among the most prominent themes linking the literature on innovation across levels and disciplines is the growing interest in the relationship between institutional context and innovative activity.

There is a strong tradition associating innovation primarily with rare entrepreneurial or inventive talent. This tradition has its roots in the early literature on economic development, particularly with the Schumpeterian (1912) characterisation of the process as one of 'creative destruction'. As Baumol (1958, p.64) pointed out nearly forty years ago, the entrepreneur is "at the same time one of the most intriguing and one of the most elusive characters in the cast that constitutes economic analysis". Attempts over the years since to pin down the definitive attributes of this elusive character have continued to meet with little success (see Burch 1986 for a typical example).

There is no doubt that rare talent plays its part in innovation activity, often in the most dramatic ways. History continues to demonstrate the impact that scientific and commercial genius can have on the growth of firms and the transformation of industries. Chester Carlson of Xerox, Edwin Land of Polaroid and Bill Gates of Microsoft, are well-known cases in point. Throughout the scientific community itself there are those like Howard Schneiderman (1991, p.55), the former vice-president of research and development at Monsanto, who remain convinced that "outstanding researchers are a rare breed" and that "most seminal discoveries are made by a handful of outstanding researchers". However, many are sceptical about the critical role of rare talent in innovation, and about the existence of a distinct entrepreneurial personality. According to Drucker (1986) innovation is essentially "organised, systematic, rational work" (p.40) in which "everyone who can face up to decision making can learn to be an entrepreneur and to behave entrepreneurially" (p.65). Furthermore, Collins and Porras (1996), in their recent study of companies that have survived and thrived for more than 40 years, have found that neither great ideas nor great and charismatic individual entrepreneurs were necessary in the building and sustaining of great enterprises.

While we can never discount the often dramatic role of rare talent in innovation, the indications from the literature, and from everyday empirical experience, are that such talent is not the definitive factor in any attempts to understand why some firms are consistently more innovative than others in the same sector, why some sectors are more innovative than others, or why innovative activity can vary so much across regions and countries. The literature across levels and disciplines is increasingly interested in understanding the characteristics of the institutional context that affect innovative activity and can help to explain these firm, sectoral and regional variations.

One of the central issues relating institutional context with innovative activity is the question of institutional form. For example, is innovative capability related to the size of firms? There is evidence that the upward trend in the average size of firms that had been an enduring feature of economic development since the industrial revolution (Galbraith 1956, Chandler 1977) has slowed down or even reversed itself since the 1970s (Peters 1992, Acs 1996), calling into question the view that there are increasing returns to scale - internal to firms - that drive successful firms to increase in size. Focusing on technology and innovation in particular, Acs and Preston (1997 p.2.) posit the question: “Is the apparent resurgence of smaller firms due to the emergence of a dynamic, vital innovative entrepreneurial sector, or is it due to the inability of large incumbent MNEs [multinational enterprises] to prevail in a technologically dynamic global environment?”

There is some evidence that small and medium enterprises (SMEs) are better innovators than their larger counterparts. This is suggested, for example, by the US data associated with Federal research funding which indicates that SMEs spend less on R&D than large firms, yet generate more new knowledge (Acs and Preston 1997). How can this be explained?

The research to date clearly indicates that the internal institutional context is an important variable. Researchers trying to understand why, often tend to start with a closer look at the more salient characteristics of the innovation process itself (Quinn 1979, Quinn 1985, Kanter 1988, Peters 1990). Most now agree that the process, in whatever organisational context, large or small, is essentially a probabilistic one, that even when well managed can best be described as one of "controlled chaos" (Quinn 1985). As Peters (1990, p.17) put it, "innovation, in the end and no matter how well thought out is a numbers game". It requires variety in idea generation, and multiple

independent approaches help to improve substantially the odds for success. It further requires a high degree of personal or group obsession to see the innovation safely through the initial period of high risk, high frustration and modest reward, since few begin as obvious commercial winners, even such classics as xerography. Successful innovation also seems to require a fair degree of personal and financial slack, the closest possible link between marketplace and technology, and a context that can tolerate and learn from failure (Quinn 1985, Kanter 1988, Peters 1990). Finally, it requires a context that values diversity, generates a marketplace for ideas and harnesses 'creative conflict' (Eisenhardt et al 1997, Leonard and Straus 1997).

Few large firms have found it easy to institutionalise such a process within traditional organisational contexts, and many entrepreneurial firms seem to lose their capacity for innovation as they grow and develop into more formal organisations over time. Quinn (1985) identified a number of very significant barriers including top management conservatism and isolation from the innovation process, intolerance for fanatics and 'non-conformist' talent, short time horizons for expected payback, excessive rationalisation and routinization of the process, excessive bureaucracy and inappropriate rewards. More generally, the traditional organisation has found it difficult to accommodate the more creative and non-conformist types who like to immerse themselves in technical challenges, often for the sheer intellectual pleasure of the chase, and whose preferred working habits tend to "contradict organizational expectations and mores" (Sinetar 1985, p58). Larger organisations are often poorer protectors of the property rights of innovators, where the gains from innovation are more diffusely distributed (Acs et al 1997), and the reward and control systems in the larger organisation are too often designed to minimise surprise, yet in the innovation process "surprises are the name of the game" (Schneiderman 1991, p.54).

However, some large firms have been able to rise to the challenge better than most, and have earned well-deserved reputations for innovativeness that have been enhanced over time. They have done this mainly by trying to recreate many of the salient characteristics of the SME within a larger organisation context. Take the example of 3M, which is increasingly being used as the benchmark by many established firms hoping to revitalise their capacity for corporate entrepreneurship. Among the most prominent features of the 3M approach is the explicit strategic commitment to competing on innovation, institutionalised in the company's ongoing formal aim that at least 25% of its sales should come from products introduced within

the most recent five-year period. Furthermore, 3M has developed a corporate culture that celebrates as heroes those enterprising individuals whose persistence and commitment have triumphed over management indifference or bureaucratic rejection. The company's '11th Commandment' is 'Thou shalt not kill a new product idea'. Its internal institutional context encourages experimentation and accepts failure as a productive stage on the road to success. It also creates structures (like the Technical Senate and the Annual Technology Fair) that facilitate grass roots scientific communication across horizontal and vertical organisational boundaries (Bartlett 1995).

Differences in internal institutional context alone will only go part of the way towards explaining why SMEs are often better innovators than their larger counterparts. There is also evidence to suggest that SMEs tend to be more actively and extensively networked into their locality/region, with implications for innovative capability. Evidence for this is provided by Almeida and Kogut (1997). Focusing on patents in the semiconductor industry in the US, they show that small-firm start-ups "are unusually oriented toward the exploration of diversity by targeting less crowded technological fields", and that the exploration of small firms "has a strong local character: they are more sensitive to, and contribute more to, the innovations of spatially-contiguous firms" (p.24.). This greater diversity among small, start-up firms is related to their 'embeddedness' (Grabher 1993) in localities. Proximity facilitates contacts between individuals that evolve into social and professional networks; these networks develop the common stock of knowledge in the locality that becomes the foundation for further innovation by starts; this is more beneficial to SMEs because the people in these firms are more likely to have had recent experience in other firms and therefore better links to other firms than personnel in large firms, which tend to be more vertically integrated and self-sufficient (Almeida and Kogut 1997). This seems to be reflected in the findings of Saxenian's (1994) ethnographic study in which she notes that there is more inter-firm knowledge exchange in Silicon Valley than in the Route 128 region around Boston; the former has a higher share of starts while the latter is dominated by larger firms that inter-relate much less either with surrounding institutions or other firms in the region. This difference is believed to be part of the reason why Silicon Valley remains vibrant while the Route 128 region has experienced a recent decline.

There is counter-argument and counter-evidence, to the effect that MNEs continue to dominate the global economy (e.g. Strange 1991, Amin 1993, Harrison 1994). Much of the research showing the advantages of SMEs is location and/or sector specific.

Rothwell and Dodgson (1994, p.310), editors of the *Handbook of Industrial Innovation*, argue that "the role played in innovation by... SMEs is strongly sectorally influenced; ...the relative innovatory roles of large and small firms can vary over the industry lifecycle; and... dynamic complementarities frequently exist between the technological change activities of large and small firms."

This is a warning against generalising in the debate on the relative advantages of large and small firms. At a level of analysis above this debate, some generalisation is however possible: for both large and small firms the influence of the institutional context on innovative activity is played out on a canvas that stretches well beyond the internal culture, structure and processes of the individual firm. As Andréosso-O'Callaghan and Jacobson (1997, p.6) have recently put it:

> *the decisions, strategies and actions of any firm evolve in a specific, regional or national, technological context, affected by a whole range of private and public institutions, and by the relationship between those institutions and firms, in short by a geographically and historically specific innovation system.*

While the systems of innovation research is still in its relative infancy, and the literature remains underdeveloped, clear strides have been made in establishing the link between wider contextual and institutional factors and firm-level innovation and in identifying the kinds of variables involved. While the question as to which domain, local, regional, national, global or sectoral, is the most salient may itself vary with context, there is little doubt that such wider systemic influences are important. For example, the financial, technical training and education, and industrial relations sub-systems, seem to be important variables in distinguishing the effectiveness of the national systems of innovation in large countries (Andréosso-O'Callaghan and Jacobson 1997). At the regional level, key variables include socio-cultural links such as common religion, artisanal training, party political membership, and strong sense of local community (Malerba 1993). Furthermore, in industrial districts like Silicon Valley, regional and sectoral influences have been found to interact to produce new structural arrangements within and between firms that affect the system of innovation not only within individual firms but more reflexively throughout the region and sector (Saxenian 1991, Bahrami 1992).

THE INNOVATION PROCESS - INVENTION, ABSORPTION AND INTEGRATION

A second major theme linking the literature across different levels and disciplines is the growing recognition that invention is only one aspect of innovation, and often not the most significant aspect. Innovation also involves processes of absorption and integration.

The tradition in western management and economics has been to associate innovation primarily with technological development, and in particular with frame-breaking technological change. When such breakthroughs happen they are often spectacular in their effects at firm, industry and national levels, as the histories of inventions like xerography, polymers and solid state electronics can attest. However, such discontinuities are relatively rare, the main benefits that flow from them do not always go to the inventing firms and their economic regions, and technological change is not the only or even the most significant form of innovation in many cases.

To date, the pattern of technological development in most industries has been one of long periods of evolution punctuated by rare episodes of radical change. Tushman and Anderson (1986), for example, found a total of just eight discontinuous changes over the combined 190-year histories of the US cement, airline and minicomputer industries up to the early 1980s. There was just one such change in the 200-year history of the Irish distilling industry (Leavy and Wilson 1994). When such radical changes have occurred, the major economic rewards have not always gone to the inventors. EMI in scanners, De Havilland in jet aircraft, and Xerox in personal computers are among the classic examples of inventive firms that failed to reap the lion's share of the economic rewards flowing from their technological breakthroughs. In many industries the technological protection regime is often quite weak, and many patents can be invented around quite easily (Teece 1986). Studies by economists like Mansfield (1984) have shown that nearly two thirds of all patented innovations are imitated legally within four years of their introduction. Resourceful imitators can often have their own versions of the technology on the market before an industry standard or dominant design has emerged. Such imitators are often better at commercialising technologies than the originators, because they have complementary assets, like an established brand name or distribution system, that prove crucial to bringing the technology to the widest possible market, and they are also better at turning the new technology into products with much greater market-appeal. Even in industries where the technological protection regime is quite strong, patient second movers, with better

applications skills and a greater commitment to developing the technology, can eventually match or even outperform the originator in reaping the commercial rewards. Canon's success in the copier industry pioneered by Xerox and Microsoft's in GUI (graphic user interface) software pioneered by Apple are just two of many such examples.

Once a new technology appears on the market the dynamics of technological development and the commercial rules of the game change at industry level (Utterback and Abernathy 1975, Utterback 1994). Speed to the market with product enhancement and process innovations to make the manufacturing system more flexible and efficient become the competitive imperatives. Proficiency in these areas depends more on development engineering capability and organisational factors than on rare scientific or technical insights. The success of many Japanese companies in securing market leadership and the technological initiative in industries like video recorders, photocopiers, quartz timepieces and dynamic random access memory (DRAM) microchips, that were originally founded on western invention, was based on what we are now coming to recognise as a capacity for 'creative imitation' (Drucker 1985; Rosenberg and Steinmueller 1988; Bolton 1993; Kim 1997).

The success of creative imitators such as Matsushita has helped to direct renewed attention in the West towards long neglected elements of the innovative process, and their links with competitiveness (see Berger et al 1989). As Rosenberg and Steinmueller (1988) have pointed out, western thinking about the innovation process has tended to focus excessively on the activities of the upstream inventor at the expense of the downstream engineer. This tendency has been underpinned by a commercial culture that has "historically cast entrepreneurs and mavericks as virtual folk heroes" (Bolton 1993, p30), and undervalued the role played by teamwork and the cumulative power of numerous ideas for incremental improvement which have so often proved the decisive advantage of the successful imitator (Reich 1987, Kanter 1988).

Creative imitation is an active learning process, backed up by well developed systems and processes for exploiting externally-developed knowledge (Bolton 1993). Cohen and Levinthal (1990, p131) refer to an organisation's ability to innovate through the acquisition and exploitation of new knowledge as its 'absorptive capacity'. The deeper and more diverse a firm's pre-existing knowledge structure, the greater is its absorptive capacity. In addition, superior absorptive capacity is a potentially difficult to imitate

source of competitiveness because of its firm-specific and cumulative nature, and it can be continually enhanced as a by-product of the firm's research and development and other knowledge-gathering activities. Creative imitation and absorptive capacity are inherently connected with an emphasis on development rather than invention, and "a central theme in the study of the development process has been its integrated, interactive, and iterative nature" (Rosenberg and Steinmueller 1988, p231). As Hamel and Prahalad (1994) have recently stressed, absorption and integration are just as central to successful innovation as invention and often the more decisive processes in industries with fairly stable underlying technological orders.

The growing recognition that innovation involves absorption and integration as well as invention has implications for our understanding of systems of innovation at all levels. We have seen earlier how prevailing mindsets and ideologies in different cultures lead to different levels of emphasis on inventive versus absorptive capacity at all levels from national economy to the individual firm (Kaplan 1987, Reich 1987, Rosenberg and Steinmueller 1988, Bolton 1993). Innovation patterns are also affected by the underlying technology regimes governing industry evolution, with implications for whether technological changes are more likely to appear from existing players or from new entrants. Malerba and Orsenigo (1997, p.84) have distinguished among two main patterns of innovation, 'creative destruction' and 'creative accumulation'. The first is a 'widening' pattern of innovation at sector level that is related to an innovation base which is "continuously growing through the entry of new innovators and to the erosion of the competitive and technological advantages of the established firms" (p.86). The second is a 'deepening' pattern that is related to "the dominance of a few firms which are continuously innovative through the accumulation over time of technological and innovative capabilities" (p.86). Others have referred to these two patterns of innovation as 'competency destroying' and 'competency enhancing' (Abernathy and Clark 1985, Tushman and Anderson 1990). Competency enhancing innovations are embedded in the technologies that they replace, like the turbofan advance in jet engines. They tend to emanate from the existing technological regime, and can propel industry evolution onto a new plane of development without any major disturbance to its existing structure.

According to Malerba and Orsenigo (1997), the competency-enhancing pattern of innovation is more likely to be found in the newer sectors of the economy like chemicals and electronics. The history of Raychem, one of the most consistently

innovative companies in the chemical sector supports this view. As Paul Cook, the company's founder and long-time chief executive explained to William Taylor of the *Harvard Business Review* some years ago (Taylor 1990, pp.98-9):

> *Too many people still think innovation is about one brilliant technologist coming up with one breakthrough idea. It's not. When we started Raychem, we began to learn what radiation chemistry could do. Within three or four years, we had generated virtually every idea behind the products that we are selling today* (over thirty years on*), and we are still working on that original inventory of ideas.*

Likewise, the leading companies in the semiconductor sector, like Intel, continue to see the technological trajectory over the next decade and beyond as very predictable, and the search for ever wider applications as the primary imperative in sustaining industry growth (Kirkpatrick 1997). Such findings and examples lend credence to belief of commentators like Reich (1987) that the collective capacity of organisations to push a basic technology in new directions, continuously refining it into a stream of new products, which can in turn spawn further competency-enhancing technological trajectories, is becoming more and more the primary engine of wealth creation in the modern economy.

The emphasis on systems and processes associated with the interest in creative imitation, absorptive capacity and cumulative change has highlighted the need to see innovation in much wider terms than that involving physical technology alone. As the recent study by Markides (1997) has shown, many other aspects of business management, including novel approaches to marketing and logistics, have been just as radical in their effects on industry evolution as technological discontinuities. In this, he provides ample support for the conclusion drawn by Abernathy and Clark (1985, p7) from their analysis of Timex's entry into the watch industry that "novelty and scientific advance may have little to do with an innovation's competitive significance". Innovations in organisation and management can be just as significant, as the MIT study of the world automobile industry has demonstrated (Womack et al 1990). In fact the rise of the new industrial powers like Japan, contrasts with the earlier experience of countries like Great Britain, Germany and the United States in being based primarily on management innovation rather than technological innovation in the more traditional sense (Drucker 1988, Stata 1989).

The emphasis on absorptive capacity and collective entrepreneurship has also focused attention directly onto the importance of institutional learning processes in competing on innovation. Stata (1989, p.64) is not alone in his view that "the rate at which individuals and organisations learn may become the only source of sustainable competitive advantage". Absorptive capacity, with its emphasis on the importance of externally-generated knowledge also broadens our perspective on innovation from the traditional focus on intra-organisational processes to inter-organisational relationships. As such it raises interesting questions about institutional learning processes not only at organisational level, but also at sector and regional levels as well, and how such learning processes are stimulated or inhibited by competitive and collaborative relationships among firms.

Traditionally, in the economics field, research on the diffusion of innovation and learning throughout industries and sectors has tended to focus on measuring rates of adoption of innovation and how they change over time (Mansfield et al, 1977). However, new approaches have emerged in more recent years, with evolutionary, path-dependency and industrial districts theorists all emphasising different factors in the diffusion process (see Lissoni and Metcalfe 1994, for a review of these developments). Many economists are coming to recognise that any single theoretical approach will only explain part of the picture. As Jacobson and Andréosso-O'Callaghan (1996, p.176) have recently argued, "human, social and even cultural factors are increasingly being accepted as important in technology, innovation and diffusion", and innovation economists are being drawn beyond the traditional boundaries of their own discipline in the search for fresh insight.

TOWARDS A FRAMEWORK FOR MULTI-LEVEL, INTERDISCIPLINARY RESEARCH

The thematic convergence across levels and disciplines reflected in the foregoing review points us towards the kind of framework within which multi-level, interdisciplinary research on innovation might be usefully developed, based on systems thinking, learning theory and dynamic analysis.

The first conclusion that we can draw from the foregoing review is that the innovation process can no longer be fully understood at any single level of analysis. This is perhaps most dramatically illustrated in the developing literature on systems of innovation, where very clearly the nature of innovative activity at firm level is seen to be

inextricably linked to institutional influences operating at national and sectoral levels. Increasingly, we consider firms in less discrete and atomistic terms in the context of industrial agglomerations like clusters, districts and filieres, with innovation emerging through supplier partnerships, strategic alliances and other forms of inter-organisation relationships (Jacobson and Andréosso-O'Callaghan 1996, pp.116-122). In short, the study of innovation increasingly requires a systems perspective.

A Living Systems Perspective

What kind of systems perspective? Much of our traditional thinking about social systems at all levels of analysis is heavily influenced by mechanistic models. As Morgan (1986, p.22) has observed "the mechanistic mode of thought has shaped our conception of what organisation is all about". However, from what we know of the nature of the innovation process in its wider institutional context, the machine model seems increasingly inappropriate as a descriptive or explanatory framework. Indeed, one of the central findings in the literature on innovation so far is that the process tends to be inhibited in organisations structured and managed along mechanistic lines. When it does work in such organisations, it is often more in spite of the institutional context than because of it (Quinn 1985, Kanter 1988). The machine model is a command and control model. It is a good model for portraying and understanding institutions as control systems, where the reliable repetition of well-defined activities is the predominant objective. However, the innovation process in institutional settings does not fit easily into such a model.

Increasingly, we are seeing the potential in more organic models or biological metaphors. The tradition of using organic analogies for the innovation process in organisational analysis goes back to the seminal study of Burns and Stalker (1961). Since then the concept of the organisation as a living system has been receiving increasing attention (Morgan 1986, de Geus 1997). The organic model has a number of features which make it a more appropriate analogue for systems of innovation than the machine model. In organic systems the relationship between the system and its component parts is more loosely coupled than that represented in the machine model, and system coherence is achieved through mutual adjustment not master-slave mechanical transmission. The components of an organic system are seen as systems-within-systems with some scope for self-directed or autonomous action. The boundaries separating the system from its super-system and sub-systems are flexible and permeable. The relationship between cause and effect is often non-linear, and

initiatives taken in any part of the system can often ramify in ways that are unpredictable at the outset. Feedback can be positive as well as negative, as ideas and innovations gather momentum and support. In an organic perspective leaders are integral elements of the system, not controlling forces that operate on it from the outside. The capacity for leadership is seen to be widely dispersed. Its exercise is always an intervention in an energy system, where energy is "a property of the system", not the leader (Bate 1996, p33). This is consistent with what we observe in the most innovative settings where leaders are seen to induce innovation rather than command it, and to do this through attention to institutional culture and context rather than through attempting to define with precision specific ends and means. Bartlett's (1995, p1) description of 3M as "a kind of corporate petri dish that fosters a culture of innovation" reflects this organic perspective, as does Kanter's (1988, 205) description of innovation in institutional and organisational contexts as the process of "making a thousand flowers bloom".

An organic systems metaphor also invites us to consider the application of an ecological perspective to innovation processes, which in itself can provide a very powerful tool for multi-level analysis. The prerequisite for the application of such a perspective is the existence of relevant population dynamics (birth-death-rebirth rates). One of the realities that such a perspective makes us face is that the processes of innovation and economic development at all levels, will always involve some such dynamics (Schumpeter 1912, Bower and Christensen 1995, Nelson 1995). However, the population dynamics relevant to innovation are not confined only to structures. Researchers like Burgleman (1991) have shown how the ecological perspective can also be applied in insightful ways to the process of technology selection, development and renewal within companies like Intel.

In short, the organic systems model seems to offer an empirically valid and conceptually sound framework through which to study innovation from a multi-level, cross-disciplinary perspective.

Learning Theory

It is also clear from the foregoing review that the concept of learning, in institutional and organisational settings, lies at the heart of all innovation systems. We saw this, for example, in the growing recognition that the absorption, integration and application of knowledge are just as essential to successful innovation in institutional contexts as is

its creation. Innovation depends as much on the ability to create, mobilise and further develop system-wide learning structures, processes and communities as it does on inventive genius. In industries with evolutionary technological trajectories, the capacity for institutional learning may be the key variable.

Placing the concept of learning at the heart of a framework for the multi-level study of innovation offers a number of attractions. To begin, with learning theory provides a conceptual basis for explaining the diverse and increasingly complex patterns of co-operation and competition that are now emerging at both sector and firm levels. At inter-organisational level we are seeing the growth of supplier-partnerships, strategic alliances and technology sharing. Such co-operative strategies allow individual firms to develop deeper, more specialised learning structures and to pool competencies across organisational boundaries in the innovation process (Hamel 1991, Dyer and Ouchi 1993, Quinn and Hilmer 1994). At firm level increasingly we are seeing companies like ABB, General Electric and IBM, decentralise into federations in an attempt to generate more vibrant learning communities than was possible under more tightly-integrated monolithic structures. Once again this combines a complex and subtle combination of competition and co-operation, competition in the generation of ideas and co-operation in their diffusion and application.

Learning theory can also help us to understand at least in part why innovation systems follow certain patterns of development over time. Many theorists point out that learning in institutional settings is itself a multi-level process. The many distinctions to be found in the literature between single-loop and double-loop learning (Argyris and Schon 1978), adaptive and generative learning (Senge 1990), higher and lower level learning (Fiol and Lyles 1985) and first-order and second-order learning (Levinthal and March 1993) may differ somewhat in emphasis, but they all converge around the recognition that the learning processes that foster efficiency in social systems are not the same as those that foster change. As Pascale (1991, p235) puts it, 'little' learning "maximizes", whereas 'big' learning "meta-mizes", and it is important for innovative systems to do both. However, experience-to-date would seem to confirm that most social systems find it difficult to achieve the appropriate balance in their learning processes between the exploitation of existing knowledge and the exploration for new knowledge that are essential to their long run stability and survival (March 1991).

This insight into the different levels of learning goes some way towards explaining why radical innovation often happens outside of existing industries and their leading incumbents (Bolton 1993), why those radical innovators that "ride an innovation to the heights of industrial leadership often fail to shift to newer technologies" (Utterback 1994, p162), and why industrial leadership "changes hands in about seven out of ten cases when discontinuities strike" (Foster 1986, p116). Established industries and their leading incumbents often progressively get locked in to lower-level learning processes in the exploitation of their existing competencies so that they become incapable of fundamental technological renewal and blind to its commercial potential (Gilad 1994, Utterback 1994). It is important, then, to be aware that the learning processes associated with innovation have potential downsides. As Levitt and March (1988, p.335) have pointed out, "learning does not always lead to intelligent behaviour" and the same processes that yield experiential wisdom in organisations and wider social systems "also produce superstitious learning, competency traps, and erroneous inferences". Furthermore, the levels of learning distinction draws needed attention to the political nature of innovation. Lower-level learning that incrementally refines and finesses an existing technological regime tends to lead to the increasing sedimentation of an established power structure and its dominance over an existing organisational paradigm or institutional world view (Johnson 1988, Pascale 1991). As a result, higher order learning rarely takes place without political action, and nearly always has political consequences (Hardy 1996, Hardy and Dougherty 1997).

A learning perspective also tends to draw our attention to other key aspects of innovation in institutional settings. In industries where creative absorption and integration are more important than pure invention, the competitive performance of any innovation system can be seen to turn on factors like the ability to accelerate institutional learning, appropriate learning opportunities, create vibrant learning communities and manage the interplay between tacit and explicit knowledge.

We know from the literature on corporate transformation and renewal that learning can be accelerated by crisis, and higher-level learning often seems impossible without it (Starbuck et al 1978, Kanter 1983, Child and Smith 1987, Pascale 1991). The more interesting question is if learning can be accelerated in a deliberate way in more favourable circumstances. Senge (1993) suggests that institutions can create aspirational crises, with similar effects. One way is to deliberately commit the institution to goals that stretch its resources and challenge its resourcefulness (Nonaka

1991, Hamel and Prahalad 1993). Canon's plunge into the office products business, Turner Broadcasting's foray into 24-hour television newscasting, and Virgin's entry into the airline business are classic examples at firm level. Kennedy's 'man-on-the-moon within a decade' space programme, and Korea's rapid rise to global industrial power are further examples at the more macro level.

A focus on learning also extends our insight into how technological leadership can be established and secured beyond patent protection. Patents protect existing knowledge. Appropriating learning opportunities protects the underlying capability that produced this knowledge in the first place. As Hamel and Prahalad (1994) have acutely observed, when a company like Canon supplies printer technology to its rivals, it is in effect borrowing their market share to accelerate its own learning and extend its hegemony over the technology's future migration. The learning perspective also helps us in extending our thinking about innovation beyond the traditional confines of research and development activity. As Brown (1991, p103) has pointed out, spontaneous innovation is happening all the time in diverse locations throughout most institutions, "wherever employees confront problems, deal with unforeseen contingencies, or work their way around breakdowns in normal procedures". The ability to convert such local insight into institutional learning is often the key to competing on innovation at all levels of the social system. According to de Geus (1997), working within a living systems perspective, this ability hinges on whether the institutional context encourages flocking or territorial behaviour. "Birds that flock learn faster, so do organisations that encourage flocking behaviour" (p57). It also hinges on the ability to manage the interplay between explicit and tacit knowledge in the innovation process (Nonaka 1991). The most proprietary elements in any institution's underlying innovation capability are often rooted in shared tacit knowledge and the "many detailed understandings" that are "intuitively developed in countless conversations", as Ravi Venkatesan (1992, p.99) of Cummins Engineering has observed. The quality of this interplay and the effectiveness of the flocking behaviour which is essential to it, may depend in turn on the degree to which the process of institutional learning has been underpinned by shared values, ideals and community spirit (Nonaka 1991, Kofman and Senge 1993).

Many of these insights find ready resonance in the economics literature, where Lundvall (1992) and others are actively attempting to merge the evolutionary, systems of innovation and learning perspectives into a more unified 'theory of innovation and

interactive learning'. Among their arguments is that advanced by Johnson (1992, p34) who suggests that innovations “are rooted both in the production structure and the institutional set-up of the economy”. They see learning and innovation as interactive, both emanating to some extent from routine activities in economic production. For them, different "technological opportunities, income elasticities and linkages between industries" can make learning in some industries and periods "much easier" than in others, and they view the innovation process as having "deep roots in the history of the economy". This does not mean that it is not amenable to better understanding by research, nor to improvement by policy. In fact, Johnson (1992, p.43) has argued for comparative studies of national systems of innovation as “a way to facilitate institutional learning and clarify the possibilities of institutional borrowing between countries”, providing a direct link with management theorists like Nonaka (1991).

Dynamic Analysis

The multi-level study of innovation, that adopts a living systems perspective and places the multi-level exploration of learning processes at the heart of the inquiry, will be concerned with change and require a dynamic mode of analysis.

The power of dynamic analysis within a systems perspective can perhaps be best illustrated with a brief reference to one of the few multi-level, interdisciplinary studies of innovation to have been carried out to date, Linsu Kim's (1997) analysis of the process of technological learning in the Korean economy. Korea's transformation from a subsistence agricultural economy to a global industrial power in less than four decades is unique in commercial history. Korea is now a leading player in the automobile, consumer electronics and semiconductor industries. The country made this transformation through a process of accelerated technological learning that spanned national, sectoral and firm levels of the social structure. As Kim (1997, p194) summarised it:

> *The diverse factors that interacted complexly to influence the direction and speed of technological learning in Korean industries are government, chaebols, education, export policy, technology transfer strategy, research, development policy, sociocultural systems, and private-sector strategy.*

Kim's analysis of the accelerated learning process in the Korean semi-conductor industry is a particularly impressive example of the kind of insight to be gained from

multi-level, interdisciplinary research on innovation of the type being advocated here. It demonstrates most forcefully how innovative capability at national, sectoral and firms levels can be developed and transformed in an interactive, non-linear, way over time.

There are as yet few definitive methodological templates for carrying out such research. One that has already demonstrated potential is the contextualist approach of Pettigrew (1985, 1990) which has been used by him in the study of strategic change. This approach is based on a number of broad principles which can be roughly distilled as follows:

(i) It involves multiple levels of analysis in connecting context, process and outcome using economic, political and cultural modes of inquiry;

(ii) Its perspective on social interaction in context is neither over-voluntarist nor over-deterministic in world view, but closer in orientation to the 'ensemble des jeux' perspective on actors and systems reflected in the work of Crozier and Friedberg (1980);

(iii) It is primarily inductive in orientation and employs intensive longitudinal comparative research strategies that allow patterns of process to unfold and reveal themselves over time.

This kind of meta-framework can provide welcome guidance to future researchers contemplating the multi-level study of innovation. However, it is not a detailed specification, which perhaps remains its major strength. It allows plenty of scope for originality on the part of the individual researcher in both the choice of substantive problem and the specifics of the research design. Multi-level research on innovation is therefore likely to remain exploratory in both substance and method for some time to come.

CONCLUSION

The multi-disciplinary aspects of this paper have followed in the first instance from the fact that the authors are management and economics academics respectively. However, the examination of the way in which the two literatures have approached innovation in recent years shows that not only does each draw on the other, but they also both draw on a number of other disciplines such as psychology, sociology and

political science. Whether because of this interactive learning in practice, or because of some more fundamental determinants, the approaches to innovation appear to be remarkably similar, irrespective of discipline. The language, techniques and focus might differ slightly, but the basic arguments are the same: attempting to understand innovation as a simple, linear process, whether within the firm or, through diffusion, between firms, results in a truncated picture at best. Innovation is complex, dynamic, spatially and historically diverse.

This brings us to the multi-level or multi-layered aspect of this work. At whatever level the focus, the argument that follows from our examination of the literature is that innovation is a consequence of processes operating at a number of different levels. Thus even if we focus on an individual innovator, the social, cultural and educational background of that individual may be important. Whether his or her innovations are accepted and diffused will depend on the nature of the production system - including the organisation of the individual's firm and inter-firm interactions of all kinds - as well as on the institutional set-up of the economy.

Why have the approaches to innovation of both management and economics moved towards an acceptance of a complex, multi-layered process? First, there is a growing awareness in both disciplines of the possibilities of cross-fertilisation. Rumelt, Schendel and Teece (1991), for example, show a whole range of cross-overs between strategic management and economics. Second, at the forefront of both disciplines are moves away from the traditional, Newtonian approaches. In management, for example, there is an increasing acceptance of limits to the role of the manager as firms become less hierarchical, more porous, more disaggregated. In economics, particularly in the study of innovation, there is less reliance on the use of mathematics in deductive theorising, and more emphasis on ex-post analysis of more disparate actors and behaviours. Elements of both disciplines seem to be entering the post-modern world in which the assumptions of order and progress are called into question, in which there is a break-down of much accepted wisdom and a break-up of many organisational forms.

On the other hand, these developments in the management and economic theories of innovation can be seen as responses to the empirical reality of tensions between globalisation, innovations, new forms of work organisation, and the increasing importance of competitiveness to firms, regions and economies. The notion that

theoretical developments are, even in part, responses to changing empirical reality is anything but post-modern (Jameson, 1991). In this paper we have identified a response on the part of academics in both management and economics to the increasing complexity, and have suggested ways of proceeding along this path.

REFERENCES

Abernathy, W.J. and Clark, K.B. (1985). Innovation: mapping the winds of creative destruction, *Research Policy* 14, pp.3-22.

Acs, Z. (ed.) (1996). *Small Firms and Economic Growth*, two volumes, Cheltenham, UK: Elgar.

Acs, Z., Morck, R., Shaver, J.M. & Yeung, B. (1997). The internationalization of small and medium-sized enterprises: a policy perspective, *Small Business Economics*, 9,1, pp.7-20.

Acs, Z. and Preston, L. (1997). Small and medium-sized enterprises, technology, and globalization, *Small Business Economics*, 9,1, pp.1-6.

Almeida, P. and Kogut, B. (1997). The exploration of technological diversity and the geographic localization of innovation, *Small Business Economics*, 9,1, pp.21-31.

Amin, A. (1993). The globalization of the economy: an erosion of regional networks? in Grabher, G. (ed.) *The Embedded Firm: on the socioeconomics of industrial networks*, London: Routledge.

Andréosso-O'Callaghan, B. and Jacobson, D. (1997). The innovation capability of EU industry in the 21st century, *Eastern Academy of Management Conference*, Dublin.

Argyris, C. and Schon, D.A. (1978). *Organizational learning: a theory of action perspective*, Reading Massachusetts:Addison-Wesley.

Bahrami, H. (1992). The emerging flexible organization:perspectives from Silicon Valley, *California Management Review* (Summer), pp.33-52.

Bartlett, C.A. (1995). 3M: profile of an innovating company, *Case # 9-395-016*, Harvard Business School.

Beck, N. (1992). *Shifting gears: thriving in the new economy*, Toronto: Harper Collins.

Berger, S., Dertouzos, M.L., Lester, R.K., Solow, R.M. and Thurow, L.C. (1989). Towards a new industrial America, *Scientific American*, 260, 6, pp.21-29.

Best, M.H. (1990). *The New Competition: Institutions of Industrial Restructuring*, Cambridge: Polity.

Blaumol, W.J. (1968). Entrepreneurship in economic theory, *American Economic Review* 58 (2), pp.64-71.

Bolton, M.K. (1993). Imitation versus innovation: lessons to be learned from the Japanese, *Organizational Dynamics* 22 (Winter), pp.30-45.

Bower, J.L. and Christensen, C.M. (1995). Disruptive technologies: catching the wave, *Harvard Business Review* 73, January-February, pp.43-53.

Brown, J.S. (1991). Research that reinvents the corporation, *Harvard Business Review* 69, January-February, pp.102-111.

Burch, J. (1986). Profiling the entrepreneur, *Business Horizons* (September-October), pp.13-16.

Burgleman, R.A. (1991). Intraorganizational ecology of strategy making and organizational adaptation: theory and field research, *Organization Science* 2, 3, pp.239-262.

Chandler, A.D. (1977). *The Visible Hand: The Managerial Revolution in American Business*, Cambridge, MA: Harvard University Press.

Child, J. and Smith, C. (1987). The context and process of organizational transformation - Cadbury Limited in its sector, *Journal of Management Studies* 24, 6,pp.565-593.

Cohen, W.M. and Levinthal, D.A. (1990). Absorptive capacity: a new perspective on learning and innovation, *Administrative Science Quarterly* 35, pp.128-152.

Cole, A.H. (1968). The entrepreneur, introductory remarks, *American Economic Review* 58 (2), pp.60-63.

Collins, J.C. and Porras, J.I. (1986). *Built to last: successful habits of visionary companies*, London: Century Business Books.

Crozier, M. and Friedberg, E. (1980). *Actors and systems: the politics of collective action*, Chicago: University of Chicago Press.

de Geus, A. (1997). The living company, *Harvard Business Review* 75, March-April, pp.51- 59.

Drucker, P.F. (1986). *Innovation and entrepreneurship*, London: Pan.

Drucker, P.F. (1988). Management and the world's work, *Harvard Business Review* (September-October), pp.65-76.

Eisenhardt, K.M., Kahwajy, J.L. and Bourgeois, L.J. (1997). How management teams can have a good fight, *Harvard Business Review* 75, July-August, pp.77-85.

Fiol, C.M. and Lyles, M.A. (1985). Organizational learning, *Academy of Management Review*, 10, 4, pp.803-813.

Forbes (1997). Steel versus silicon, *Forbes* (July 7th), pp.129-140.

Galbraith, J.K. (1956). *American Capitalism: The Concept of Countervailing Power* (2nd Edition), Boston: Houghton Mifflin.

Gilad, B. (1994). *Business blindspots*, Chicago: Probus.

Grabher, G. (ed.) (1993). *The Embedded Firm: on the socioeconomics of industrial network*, London: Routledge.

Hamel, G. and Prahalad,C.K. (1993). Strategy as stretch and leverage, *Harvard Business Review* 71, March-April, pp.75-84.

Hamel, G. and Prahalad, C.K. (1994). *Competing for the future*, Boston: Harvard Business School Press.

Hardy, C. (1996). Understanding power: bringing about strategic change, *British Journal of Management*, Special Edition, pp. S3-S16.

Hardy, C. and Dougherty, D. (1997). Powering product innovation, *European Management Journal*, 15, 1, pp.16-27.

Harrison, B. (1994). Concentrated economic power and Silicon Valley, *Environment and Planning - A*, 26,2, pp.307-328.

Jacobson, D. (1994). The technological and infrastructural environment, in N. Nugent and R. O'Donnell (eds.), *The European Business Environment*, London: Macmillan.

Jacobson, D. and Andréosso-O'Callaghan, B. (1996). *Industrial Economics and Organization: A European Perspective*, London: McGraw-Hill.

Jameson, F. (1991). *Postmodernism, or, The Cultural Logic of Late Capitalism*, London: Verso.

Johnson, B. (1992). Towards a new approach to national systems of innovation, in Lundvall (ed.) *National Systems of Innovation.*

Johnson, G. (1988). Rethinking incrementalism, *Strategic Management Journal*, 9, pp.75-91.

Kanter, R.M. (1988). When a thousand flowers bloom: structural, collective and social conditions for innovation in organisations, *Research in Organizational Behavior*, 10, pp.169-211.

Kaplan, R. (1987). Entrepreneurship reconsidered: the anti-management bias, *Harvard Business Review* 65 (May-June), pp.84-89.

Kim, L. (1997). *Imitation to innovation: the dynamics of Korea's technological learning*, Boston: Harvard Business School Press.

Kirkpatrick, D. (1997). Intel's amazing profit machine, *Fortune*, February 17th, pp.24-30.

Kofman, F. and Senge, P.M. (1993). Communities of commitment: the heart of learning organizations, *Organizational Dynamics* 22, Autumn, pp.5-23.

Leavy, B. and Wilson, D. (1994). *Strategy and leadership*, London: Routledge.

Leavy, B. (1997). Innovation and the established organisation, *Journal of General Management*, 22, 3, pp.38-52.

Leonard, D. and Straus, S. (1997). Putting your company's whole brain to work, *Harvard Business Review* (July-August), pp.111-121.

Levinthal, D.A. and March, J.G. (1993). The myopia of learning, *Strategic Management Journal*, 14, pp.95-112.

Levitt, B. and March, J.G. (1988). Organizational learning, *Annual Review of Sociology*, 14, pp.319-340.

Lissoni, F. and Metcalfe, J.S. (1994). Diffusion of innovation ancient and modern: a review of the main themes, in M. Dodgson and R. Rothwell (eds.) *Handbook of Industrial Innovation*, Aldershot: Elgar.

Lundvall, B-Å (ed.) (1992). *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Pinter.

Markides, C. (1997). Strategic innovation, *Sloan Management Review* (Spring), pp.9-23.

Malerba, F. (1993). The national innovation system: Italy, in R.R. Nelson (ed.), *National innovation systems: a comparative analysis*, Oxford: Oxford University Press.

Malerba, F. and Orsenigo, L. (1997). Technological regimes and sectoral patterns of innovative activities, *Industrial and Corporate Change*, 6, pp.83-117.

Mandel, M.J. (1997). The new business cycle, *Business Week* (March 31st), pp.48-54.

Mansfield, E. (1984). R&D and innovation, in Z.Griliches (ed), *R&D patents and productivity*, Chicago: University of Chicago Press.

Mansfield, E. et al. (1977). Social and private rates of return from industrial innovations, *Quarterly Journal of Economics*, 10, pp.221-240.

March, J.G. (1991). Exploration and exploitation in organizational learning, *Organization Science*, 2,1, pp.71-87.

Nelson, R.R. (ed.) (1992). *National systems of innovation*, Oxford: Oxford University Press.

Nelson, R.R. (1995). Recent evolutionary theorizing about economic change, *Journal of Economic Literature*, 33,1, pp.48-90.

Niosi, J. and Bellon, B. (1996). The Globalization of National Innovation Systems, in J. de la Mothe and G. Paquet (eds.), *Evolutionary Economics and the New International Political Economy*, London: Pinter.

Nonaka, I. (1991). The knowledge-creating company, *Harvard Business Review* 69, November-December, pp.96-104.

Pascale, R.T. (1991). *Managing on the edge*, Middlesex: Penguin.

Pascale, R.T. and Athos, A.G. (1981). *The art of Japanese management*, New York: Simon and Schuster.

Peters, T. (1990). Get innovative or get dead, *California Management Review* 33, 1, pp.9-26.

Peters, T. (1992). Rethinking scale, *California Management Review*, Fall, pp.7-29.

Pettigrew, A.M. (1985). *The awakening giant: continuity and change in ICI*, Oxford: Blackwell.

Pettigrew, A.M. (1990). Longitudinal field research on change: theory and practice, *Organization Science*, 1, pp.267-292.

Quinn, J.B. (1979). Technological innovation, entrepreneurship, and strategy, *Sloan Management Review* (Spring), pp.19-30.

Quinn, J.B. (1985). Managing innovation: controlled chaos, *Harvard Business Review* (May- June), pp.73-84.

Reich, R. (1987). Entrepreneurship reconsidered: the team as hero, *Harvard Business Review* 65 (May-June), pp.77-83.

Rosenberg, N. and Steinmueller,W.E. (1988). Why Americans are such poor imitators, *American Economic Review* 78, pp.229-234.

Rothwell, R. and Dodgson, M. (1994). Innovation and size of firm, in Dodgson, M. and Rothwell, R. (eds.) *The Handbook of Industrial Innovation*, Aldershot: Elgar.

Rumelt, R., Schendel, D. and Teece, D.J. (1991). Strategic Management and Economics, *Strategic Management*, 12, Special Issue, pp.5-29.

Saxenian, A. (1991). The origins and dynamics of production networks in Silicon Valley, *Research Policy* 20, pp.423-437.

Saxenian, A. (1994). *Regional Advantage*, Cambridge, MA: Harvard University Press.

Schneiderman, H.A. (1991). Managing R&D: a perspective from the top, *Sloan Management Review* (Summer), pp.53-58.

Schumpeter, J.A. (1912). *The theory of economic development*, Oxford: Oxford University Press.

Senge, P.M. (1990). The leader's new work: building learning organizations, *Sloan Management Review*, Fall, pp.7-23.

Senge, P.M. (1993). Harnessing the power of organizational learning, *Network* 6, 6, pp.4-5.

Sinetar, M. (1985). Entrepreneurship, chaos and creativity - can creative people really survive large company structure?, *Sloan Management Review*, Winter, pp.57-62.

Starbuck, W.H.,Greve,A. and Hedberg,B.L.T. (1978). Responding to crises, *Journal of Business Administration* 9,2, pp.111-137.

Stata, R. (1989). Organizational learning: the key to management innovation, *Sloan Management Review* (Spring), pp.63-74.

Strange, S. Big business and the state, *Millenium: Journal of International Studies*, 20,2, pp.245-250.

Taylor, W. (1990). The business of innovation: an interview with Paul Cook, *Harvard Business Review*, March-April, pp.97-106.

Teece, D.J. (1986). Profiting from technological innovation: implications for integration, collaboration, licensing and public policy, *Research Policy* 15, pp.285-305.

Tushman, M.L. and Anderson, P. (1986). Technological discontinuities and organizational environments, *Administrative Science Quarterly* 31, pp.439-465.

Utterback, J.M. (1994). *Mastering the dynamics of innovation*, Boston: Harvard Business School Press.

Utterback, J.M. and Abernathy, W.J. (1975). A dynamic model of process and product innovation, *Omega* 3(6), pp.639-656.

Venkatesan, R. (1992). Strategic sourcing: to make or not to make, *Harvard Business Review* 70, November-December, pp.98-107.

Womack, J.P., Jones, D.T. and Roos, D. (1990). *The machine that changed the world*, New York: Rawson Associates.