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GEOGRAPHIES OF KNOWLEDGE FORMATION INFIRMS

Ash Amin and Patrick Cohendet

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Introduction

In the history of thought on economic knowledge, Time has long been recognised as a significant actant, while Space has remained a poor cousin, little more than a local perturbation with no significant role to play in the dynamic of knowledge-creation. This situation has improved in recent years, as a result of the work of institutional and evolutionary economists and economic geographers on how proximity and local embeddedness influence business innovation. But, in these still early beginnings of spatial theorisation, the inclination has been to see space in primarily territorial terms or as an artefact of co-location, rather than through its varied compositions – distance, mobility and travel, virtuality and immanence – and their enrolment into knowledge formation.

This paper works with an expanded definition of space, one that recognizes territorial placements but also other spatial arrangements. It does not assume that knowledge falls into bundles organized along neat geographical scales and contours (e.g. that tacit knowledge requires spatial proximity while codified knowledge is ubiquitous or that knowledge externalities are spatially agglomerated). Instead, it starts with the pragmatist

premise that spaces of knowing are tracings of the ways in which actants – human and transhuman – mobilize and align themselves in pursuit of particular corporate goals. These tracings are shaped by actant activity and organizational architecture, thus, depending on circumstances, they can involve all manner and combination of spatial mobilisations, including placements of task teams in neutral spaces, face-to-face encounters, global networks held together by travel and elaborate communications networks, virtual communities, and corporate thought experiments, symbolic rituals and cultures of belonging. All of these, and not the character of local and national systems of innovation, must be counted as spaces of learning.

The first part of the paper summarises the new spatial sensibility that has emerged in recent years and engages with its central claim that spatial proximity and territorial agglomeration generate distinctive or superior learning advantages. The second part develops an alternative spatiality centred around the forcings of corporate organisation; forcings that permit relational proximity at a distance, render knowledge indivisible, and continually expand into new spatial configurations such that no single dimension of space can be privileged.

Space as an island of innovation

Two forms of territoriality have come to be emphasised in evolutionary and institutional economics and economic geography, as influences on knowledge formation. In the first stage, during the 1990s, research focused on the role of *national* systems of innovation (Lundvall and Johnson, 1994; Amable, 2000; Hollingsworth, 2000; Gertler, Wolfe and Garkut, 2000). It showed how firms are influenced by the quality of ‘home base’ institutions that act as a collective resource for both technological and non-technological innovation and learning. These include the national science and technology base, the quality of education and training and links with the business system, the information and communications infrastructure, the policies of financial institutions towards innovative or risky business ventures, public policies on trade, industry and technology, and the norms, values and practices ingrained within the national business and industrial relations cultures. This institutional set up, which varies from country to country and from region to region, is said to constitute the location-specific supply base of technological and knowledge externalities that firms draw upon for their competitiveness, and also shape the type of innovation and learning that takes place.

More recently, attention has shifted to another aspect of spatial proximity, relating to the perceived benefits of *industrial agglomeration and spatial proximity* between firms. This research builds on work on agglomeration economies to explore the implications of industrial clustering for innovation and learning. Clustering is said to help stimulate knowledge flows through the formation of up-stream and down-stream linkages between firms (Porter, 1995), raise local know-how through labour pooling and product specialisation, allow the circulation of ideas and know-how through local labour mobility (Breschi and Malerba, 2001; Glaeser, 1998), and generate knowledge spillovers in the local industrial atmosphere (Marshall, 1920) associated with product specialisation. In another version, relating to claims about the varied geographies of tacit and codified

knowledge, it is argued that while codified knowledge can be dislocated from its originating setting and made ubiquitous, tacit knowledge is 'context-dependent, spatially sticky and socially accessible only through direct physical interaction' (Morgan, 2001: 15). Competitive advantage, thus, is said to derive from the composition of local ties, around the assumption that 'social learning processes work smoothly between entrepreneurs in a cluster compared to the outside world, because of an abundance of strong and weak ties ... facilitated by the geographical proximity of local entrepreneurs. Proximity promotes face-to-face interactions along with monitoring and gossip, and hence shared experiences and points of reference' (Lorenzen and Foss, 2002: 10). And the consequence is that 'co-located firms ... tend to experiment with a variety of approaches and solutions to similar problems, spurred in this activity by the incentives and the opportunities provided by the possibility of constantly monitoring, comparing, selecting, and imitating the solutions chosen 'next door'' (Breschi and Malerba, 2001: 827).

The fundamental insight provided by both the national systems of innovation perspective and the local agglomeration perspective is that *territoriality* matters for innovation, respectively in the shape of national or regional institutions of knowledge formation, and in the milieu for innovation generated by local networking. This is an important insight. It compensates for the blindness in mainstream economics towards space in accounting for economic behaviour and knowledge formation.

This new spatial awareness is beginning to infect the increasingly fashionable literature on the social anthropology of innovation. We see this in the literature on communities of practice as prime knowledge-generating environments. For example, in their book *The Social Life of Information*, Brown and Duguid (2000) agree that local clusters can be seen as 'ecologies of knowledge', on the grounds that 'knowledge that sticks within firms quickly finds ways to flow between them', such that in clusters, 'firms keep a constant benchmarking eye on each other [and] the ecology develops as a whole ... turbocharged by feedback loops that run both within and between firms' (p. 165). A similar turn towards the local seems to be apparent in studies in the sociology of science, which, for years, have tended to treat space as a network of distributed threads of organisation. For example, in a recent account of why Russian successes in measuring the quality of sapphire have only recently been replicated in the West, Collins (2001) argues that much of the inability has been due to vital differences in tacit knowledge cultures between laboratories that prevent the transfer of know-how.

In summary, the recent 'spatial turn' in studies in innovation and learning has come to offer a powerful set of arguments – and considerable case evidence – in support of the argument that businesses are locked into territorially defined institutional arrangements and social relations that nourish/hamper their creativity and adaptability. Earlier observations on the integration of firms in national systems of innovation have been accompanied by a new interest in the powers of local clustering and networking, but what seems to underlie both perspectives is a reading of innovation as an 'island' activity. The geography of innovation is seen in terms of islands of innovation, in which internal links

or 'home base' characteristics, distinguishable from external and distant or omnipresent forces, drive business creativity and performance.

A distanciated sociology of learning

In what follows, our aim is not to take issue with the geographical imagination. We too believe that space lies at the heart of knowledge formation. Instead, our aim is to take issue with a particular kind of geographical imagination, one that sees 'being there' only in terms of spatial proximity. We question a conceptualization of knowledge space based on the distinction between *place* defined as the realm of near, intimate and bounded relations, and *space* defined as the realm of far, impersonal and fluid relations. It is just this kind of dualism that has allowed commentators to associate tacit knowledge with spatial proximity, and codified knowledge with ubiquity. Against a territorial reading that fashions boundaries around locations on a map, we develop a topological map arranged around relational knowledge associations, thus allowing ties between geographically distant plane can also be acknowledged as in the space of 'being there'. We take knowledge as distributed and multiplex, with individual sites acting as sites of trans-scalar and non-linear connections and as a relay point of circulating knowledges that cannot be territorially attributed with any measure of certainty or fixity.

Our prime aim is to argue that relational or social proximity involves much more than 'being there' in terms of physical proximity: face-to-face contact, local ties, 'the 'home' base, and the like. Crucially, if the social architecture of learning in firms is not reducible to territorial ties, there is no compelling reason to assume that local ties are stronger or better than ties at a distance. Of course, many relational ties *may be* localized, as in a community of practice made up of employees in a given workplace, but many others - of no less commitment and intensity - rely on a spatially 'stretched' connectivity (Amin and Thrift, 2002). This includes ties among enthusiasts with like interests (e.g. vegetarians, DIY groups, road protestors, clinical psychologists) held together by cheap travel, the Internet, and specialist literature. It also includes diaspora communities based on migratory ties and transnational cultural connections, such as business professionals and consultants. These 'distanciated' relationships describe another spatiality of knowing, one that cannot be reduced to a spatiality of bounded places, as Allen (2000) notes:

The translation of ideas and practices, as opposed to their transmission, are [*sic*] likely to involve people moving to and through 'local' contexts, to which they bring their own blend of tacit and codified knowledges, ways of doing and ways of judging things. There is no one spatial template through which associational understanding or active comprehension takes place. Rather, knowledge translation involves mobile, distanciated forms of information as much as it does proximate relationships (p. 28).

This provides the possibility, as we argue below, of recognising spaces of knowledge that draw on far more than spatial proximity, and which, significantly, also script the life of territorial clusters.

Knowledge in Relational Spaces

Nonaka and Konno (1998) have suggested that the Japanese philosophical concept 'ba' (roughly translated as 'place') helps to highlight that the 'shared space for emerging relationships' is the 'foundation in knowledge creation' (p. 40). Implicit in the typology of different forms of ba they identify is an acknowledgement of the varied spatiality of these forms of engagement. According to Nonaka and Konno, ba 'can be physical (e.g. office, dispersed business space), virtual (e.g. e-mail, teleconference), mental (e.g. shared experiences, ideas, ideals), or any combination of them.' (p. 40). Thus, while they acknowledge that physical proximity, say in the form of face-to-face contact, does undoubtedly support relational proximity, they are clear that virtual spaces as well as cultural or ideational spaces also count as spaces of relational knowledge. They are not somehow less social, less tacit, less sticky, less negotiated.

Nonaka and Konno's notion of place, liberated from territorial/physical connotations is compelling, in that it allows the possibility of relational learning at a distance. It certainly clears the ground for grasping knowledge practices within multi-locational firms, by allowing such firms to be seen as both sites of decentred learning in local communities of practice (as currently emphasized in the literature on corporate learning) as well as organizational structures that allow distanced learning to take place, of both an explorative and exploitative nature.

In the 'islands of innovation' perspective, now gaining considerable ground in theorisations of innovation and knowledge creation within multi-locational firms such as TNCs (Dunning, 2000), the diagram of knowledge drawn is decidedly decentred, composed of local R&D, local competences and capabilities, and local knowledge networks exploiting the powers of proximity (Howells, 2000, Zander, 1999). While the persistence of an international division of labour is acknowledged, with the 'home base' still a significant site of strategic innovations and patenting activity (Cantwell and Iammarino, 2001), it is argued that the old corporate model of centralized and hierarchically transmitted knowledge has been undermined by the rise of differentiated markets, shortened product life-cycles and product-to-market times, and increased demand for knowledge inputs. These changes are seen to be encouraging the rise of the heterarchical firm – decentralized and immersed in a web of global and local alliances, partnerships and supply relationships with other firms – reliant upon a system of dispersed (and locally rooted) knowledge resources. In this account, corporate knowledge is mapped as a loosely held string of islands: each island generating its own specific, but especially tacit, knowledge (Cantwell and Santangelo, 1999), with everything in between – from management devices and organizational arrangements to logistics and communications networks – concerned with aligning, converting or transmitting the diverse local knowledges.

However, it could be argued that part of the purpose of modern organization has been to make 'everything in between' to do more than to align dispersed competences, to make it count as a formative space. It has been to enable proximity at a distance, in the service of the various forms of relational *ba* outlined by Nonaka and Konno through the

organization and mastery of space. Without doubt, one of the achievements of corporate form, the rules and practices of technological ordering and spatial distribution, and the conventions of communication, command and control, is to hold varied knowledge architectures in place and establish knowledge coherence across different spatial sites. But, through complex network formation and network management devices, another important achievement has also been to find ways of 'being there' through regular and frequent contact between distributed communities, the formation of task-forces and project teams dislocated from their sites of regular work, the travels of tacit knowledge carried by executives, scientists and technicians, the movements and transmissions of knowledge embodied in varied technologies, the insights generated during occasional meetings, teleconferences and telephone conversations or in email messages sent in transit.

Aided by the architecture and tools of corporate organization, a disconnected spatial ecology of knowledge can be held in place as relational knowledge. 'Being there' is no longer a constraint of geographical proximity. This is not to suggest that the nature and quality of near and distanced relational links are the same. Malmberg (2002: 16-17) notes, for example, that in the 'local circuit', 'the likelihood of regularly meeting, and gradually developing a relation, with another person is infinitely greater', and that 'interactions are characterized not just by being unstructured, unplanned, but also relatively broad and diffuse and sometimes unwanted and often seemingly of little immediate use'. In contrast, for Malmberg, interactions in the 'global circuit' do not come by chance - 'they are often the result of devoted and targeted identification of specialist people', and they require 'a lot (time, money, energy) in order to establish their relations'. Whatever the accuracy of this comparison, its significance lies in illustrating that both spaces are interactive spaces, conceived as circuits of supporting relationally-based knowledge.

Indeed, within given corporate parameters, and with the aid of varied mechanisms for distributed organization, these two circuits fold into each other into one space of more or less long, more or less frequent, interactions. The result is a blurring of the distinction between relations in the local circuit and those in the global circuit and a growing interdependence between them. Thus, for example, the serendipity of casual contact during transit, on a visit to an affiliate unit, or through free surfing or discussion groups on the intra-net, might match the serendipity that Malmberg reserves to the local circuit. Most importantly, as part of a distinctive set of corporate connections and obligations, these travels – physical and virtual - blend into the rhythm of work, such that the practices of knowing in any single site can no longer be described in terms of a 'local' versus 'global' distinction.

In emphasising spatial blending here and in the examples that follow, our intention is not to flatten the power dynamics of distributed corporate networks. Our focus is on the quality of relational possibilities at a distance and in close proximity. The power dynamics are never matters of blending or a continuum between major players and others battling for independence and dependent on ecologies of creativity and experimentation that are organizationally, culturally, and symbolically *decoupled* from the corporate ties.

Rarely are the networks – and therefore also their learning dynamics and distribution of rewards - composed of smooth and neat complementarities and mutual benefits between actors that are linked in the overlapping global and local circuits.

Spatial Strategies

The enrolment of actors at a distance into a relational field is a prime feature of the history of ‘long-distance corporations’. In an innovative paper on scientific discovery in sixteenth century Europe, Harris (1998) shows that long-distance corporations such as the Spanish colonial House of Trade, the Dutch East India Corporation, and the Society of Jesus - all possessing considerable global reach - played a critical role in instituting medical, cartographic, biological, and botanical discoveries through a ‘kinematics of scientific practice’ based on the to-and-fro of knowledgeable people and a vast variety of knowledge objects such as maps, quadrants, dials, chronometers, compasses, logs, descriptions, and correspondence. Harris explains:

... the long-distance corporations – that is legally constituted corporations that had more or less mastered the operation of long-distance networks – had immediate institutional need of certain forms of natural knowledge and therefore incorporated knowledge-gathering and knowledge-producing mechanisms into their social fabric. These practices, though directly related to academic and bookish disciplines we think of as scientific, were situated in the *vita activa* of a corporation’s membership and were necessary tools in the prosecution of corporate agendas. Moreover, the dedicated channels of communication required in the operation of long-distance corporations facilitated the movement of personnel, texts, and objects in both the pre- and postproduction phases of knowledge-making. ...the long-distance corporation is an especially promising research site for the integration of local or embedded knowledge on the one hand and geographically distributed practices on the other (p. 271).

The modern corporation is a masterly achievement along these lines, now doing most of the above within its own corporate boundaries and through other networks under its control and influence. And as such an entity, it may well face distinctive challenges, such as how to shape path-dependencies and inertia based on accumulated knowledges, how to manage a system of distributed knowledge, and how to balance exploration of new knowledge with exploitation of existing knowledge. But, like the long-distance corporation of old, it draws upon a fine network architecture and a whole array of governance technologies to make sense of varied, often conflicting, knowledge domains, each with its own spatiality. Like the old long-distance corporation, it seeks to achieve relational proximity through translation, travel, shared routines, talk, common passions, base standards, brokers, epistemic and community bonding, and the ordering and orientation provided by files, documents, codes, common software, and so on. Thus, there is no compelling reason, as Harris notes, that when ‘one speaks of “local”, “situated” or “embedded” knowledge, the implication’ must be ‘that the narrative is somehow confined to a small “space” – if not in the literal sense of a geographic metric,

then at least in the sense of a restricted social, cultural, and temporal metrics' (1998: 296). Corporate organization, with all its devices, is the banal means by which knowledge spaces made up of bits and pieces from all over are mobilized.

Through the tools of organization, corporations have been able to develop complex spatial strategies in service of innovation and learning, strategies that involve more than reliance on the powers of proximity and avoidance of the perils of distance (Yeung, 2001). Gupta and Govindarajan (2000) go so far as to claim that 'the primary reason why MNCs [multinational corporations] exist is because of their ability to transfer and exploit knowledge more effectively and efficiently in the intra-corporate context' (p. 473). They readily acknowledge that this 'does not in any way imply that such knowledge transfers actually take place effectively and efficiently on a routine basis' (p. 474), but are dependent upon local knowledge capabilities, subsidiary-parent and subsidiary-subsubsidiary relations, richness of transmission channels, local motivational or absorptive capacities, and so on. These skeletal elements are 'worked' in different ways by different types of corporation, so, for example, Gupta and Govindarajan find that knowledge inflows from peer subsidiaries are higher among subsidiaries that are integrated more tightly with the rest of the corporation through formal mechanisms and subsidiaries 'whose presidents have been involved in lateral socialization mechanisms with peer subsidiaries to a greater extent (p. 488). The point we wish to draw for our purposes is that 'nodal' knowledge, that is the know-how of individual units, is not a 'local affair' but is shaped by flows from elsewhere in the corporation, parent policies and cultures, inter-nodal socialisation patterns, and other spatial strategies of corporate mobilisation for innovation and learning. These spatial strategies are also a means through which dispersed knowledge communities can be linked together.

The spatial strategies come in many forms that are hardly recognized in theorisations of the spatiality of corporate knowledge. One of these is the strategy of displacement. There are sites set up for new epistemic communities or projects that cannot be boxed into existing spatial arrangements, but which are crucial for generating path-breaking innovations. For example, Schoenberger (1999), who supports the new localism thesis that the multi-locational firm can no longer ignore local corporate cultures as sites of learning, is quick to note that when the firm 'realizes it needs to change', it may 'consciously set out to create a new kind of place within the firm', including 'organizational and geographical separation from the centre' (p. 216). Project teams and task forces are a typical example, dislocated from usual places of work or established R&D centres, and bringing together project-centred specialists from different locations within the firm. Lee (2002), for instance, shows that some of the Korean conglomerates that have had to restructure and adapt radically after the East Asian crisis, are increasingly relying on such sites, where teams constructed from different locations in Korea live together for weeks or months to develop new ideas.

Of course, the sociology of learning in these temporary and displaced communities draws centrally on co-presence (as argued by proponents of the localisation thesis), but mobility is also built into the act of displacement, knowledge transfer and application of new knowledge. Old and new knowledge translates back and forth from these sites with the

specialists and the artefacts they carry with them, and through the communications networks they use. This process of translation is very much part of the circuit of knowledge creation, not least because new insights and discoveries need to be understood and aligned at destination sites. Placement is tied up with mobility, and which aspect is privileged (by scholars and firms) is a matter of emphasis. For example, in the McKinsey corporation, project development teams, reveals Hargadon (1998: 218), 'are not traditionally co-located or isolated from the rest of the firm', but 'consist of consultants working out of offices across the country' as this 'gives the team access to the most resources within the organization because each individual team-member knows and regularly talks to their colleagues back at the office'.

The corporeal space of displacement as a stimulus for creativity can be light and performative, which adds another interesting twist to the relational versus physical interpretation of knowledge spaces. Hatch (1999), for example, writes of 'empty spaces' in organizations, to distinguish spaces for creative action that are not regulated by rules and norms and act as working and thinking spaces that are not easily located spatially or structurally. Hatch argues that organizational creativity can be viewed in terms of the achievements made possible by ambiguity and emotion (and also tempo) exploited during the empty spaces of improvisation in jazz. Innovation in jazz occurs when the openness in a structure of a tune 'permits any of the musicians to take the tune in a variety of directions' (p. 85) and use of the ambiguity opened up by empty spaces in the tune. For Hatch, the strategic use of ambiguity in organizations can have a similar effect, if structure and script are moulded in a way that allows most to be made of the open space between common orientation and overarching purpose on the one hand, and different beliefs and incommensurable actions on the other hand.

Similarly, she argues that just as 'groove and feel' are built into the rhythm and tempo of jazz (i.e. a structural aspect), organizations can mobilize 'structure as emotion' (p. 89) by attending to 'liking and interpersonal attraction', 'intimacy based in shared action' and emotional 'performativity' (p. 89) as a way of allowing emotions to be communicated, and through this, unlocking creative impulses. Hatch explains:

If work processes have rhythm, harmony, groove and feel, then the jazz metaphor suggests developing emotional and bodily sensitivity to work. One place to look for evidence of the effectiveness of such a strategy might be the outdoor development programmes in which many organizations have invested considerable time and money The contributions of such programmes can be perhaps better understood using concepts such as rhythm, harmony, groove and feel that are connected by the jazz metaphor to concerns for entrainment and flow. That is, team members who are in touch with their bodies and emotions may be better able to develop rhythm, harmony, groove and feel in their work processes which will enhance communication and the collaborative potential of their teamwork' (p. 90).

The use of emotions has become big business in the field of organizational mobilisation, occupying centre stage in magazine accounts of fast companies, class time in MBA

programmes, the attention of corporate training and performance units, and the imagination of a whole new industry of allegedly creativity-unlocking consultants and event providers. Things have moved far beyond crude attempts to inculcate loyalty through company songs and company jollies, into the realm of sophisticated uses of spaces of emotional performativity to generate novelty and 'groove and feel'. These include enactments of plays, simulations of problems, musical performances, role playing, deliberate and aggressive group confrontations, exhortations of guilt and exaltation, and application of softer 'new age' therapies such as meditation and spiritual chanting (Thrift, 2000; Spinoza, Flores and Dreyfus, 1997).

In all of the above examples of knowledge generation, it is relational proximity, achieved through a variety of spatial mobilisations, that stands out. We are beginning to see a similar shift in register in the literature that has grown emphasising the learning effects of joint ventures and strategic alliances. Hitherto, it is the transfer of formal knowledge (e.g. R&D, product specifications, new jointly-developed codified knowledge) that has been stressed, possibly influenced by the assumption that non-sticky knowledge is best suited to travel over the long distances that normally characterize such forms of inter-firm collaboration. Now, however, the networks of collaboration are seen as possessing inimitable resources that are derived from the structure of the networks themselves, resources with learning advantages associated normally with relationally generated social capital. For example, Gulati, Nohria and Zaheer (2000: 212) argue that:

Firms are highly alert when they create and utilize wide-ranging information networks with plentiful weak ties, high centrality, and wide geographical scope, and together with responsiveness, this capability translates into superior performance. The private and invisible nature of the ties renders the network inimitable, and thus too the information that it provides.

Inkpen (1996) has developed this thinking further by providing an illustration of how the 'soft' infrastructure of alliance knowledge works. In answering why 'some firms actively seek to leverage alliance knowledge while others make only a minimal effort' and why 'are some firms more effective at leveraging alliance knowledge' (p. 131), he identifies six factors (on the basis of evidence drawn from international joint ventures in the auto industry). The first is flexible learning objectives and expectations, that is, an open attitude to the venture. The second is leadership commitment to the joint venture, which can drive the experiment forward when exit tendencies prevail. The third is a climate of trust between partners, often enhanced by a history of ties between them. The fourth is tolerance for redundancy, or a 'conscious overlapping of company information, activities, and management responsibilities' (p. 134) that serves to lubricate dialogue and understanding, and through this, stimulate collective learning. The fifth is 'creative chaos', that is the ability of managers to channel conflict, difference and misunderstanding between partners for creative ends. The sixth factor he identifies is the avoidance of 'performance myopia' and acceptance of the joint venture as a firm-bending experiment with a longer-term payoff.

What is striking about Inkpen's list of factors – whether we agree with it or not - is that it replicates – now over very long distances – many of the relational qualities claimed by the exponents of the islands of innovation perspective as properties of local clusters. Conceptually, the overlap of knowledge work in physically proximate and distant networks (aided in the case of the latter by corporate organization, virtual communications, travel, displacement and new inter-firm networks) forces reconsideration of the territorial moorings of knowledge.

Circulating Knowledge

One clear implication of the argument we have been developing is that knowledge is not fixed to particular sites (geographical locations or network sites). The 'stickyness' of knowledge in these sites, be they clusters or R&D units or brainstorming events, stems from the unique interactions and combinations of bodies, minds, speech, technologies and objects that can be found there, crystallized in a set of local practices of doing, interpreting and translating or perhaps even in a momentary flash of inspiration. It has little to do with 'native' practices or locally confined assets. If there is a boundedness to the knowledge generated in each site, it is a feature of its entrapment and nodal position within specific actor-networks of varying spatial composition and reach, not a feature of local confinement.

This is how we interpret the awareness of situated knowledge that has grown in recent years thanks to the literature on the sociology of science. This literature has been concerned 'to show in concrete detail the ways in which the making, maintaining, and modification of scientific knowledge is a local and mundane affair' (Shapin, 1995: 304): a reading with profoundly different policy implications than current emphases on top-down science. Interestingly, though, what is meant by 'local' is not reducible to geographical location. Shapin, for example, has noted four dimensions of this 'localist' turn in science studies: first, science-making as a 'mundane matter', accounted for by human cognitive capacities and ordinary forms of social interaction'; second, the work of persuasion and enrolment through various means in translating and generalising findings from any one site; third, the 'embodied character of scientific knowledge', 'reposed in skilled people, in scientific instruments, or in the transactions between people and knowledge-making devices'; and fourth, the 'physical situatedness of scientific knowledge-making' in sites that can vary from 'the personal cognitive space of creativity, the relatively private space of the research laboratory, the physical constraints posed by the natural or built geography..., the local social spaces of municipality, region, or nation, or the 'topical contextures' of practice, equipment, and phenomenal fields' (p. 306).

The local, or bounded, nature of knowledge here is taken as the entanglement of human and non-human practices that make up the everyday - knowledge in action – drawing upon a varied spatial ecology of impulses and inputs. The local is not the spatially confined. The sites are recipients, combiners, and transmitters of what can be considered to be travelling or circulating knowledge, coming in bits from a number of distances and directions and in varied forms. Viewed in this way, the knowledge work and challenges

of individual sites might be seen as focused less on mobilising and taking advantage of local tacit knowledge or other indigenous capabilities, than on working with and making sense of knowledge – in all its forms – as an immanent and circulating force. But their task should not be seen as that of pinning this circulatory force down or through other metaphors of fixing, slowing down, or containing, but as a task of making, aligning and ordering relational networks made up of a multitude of potential knowledge actants. It is about acting at a distance and managing circulating knowledge by bringing into play (or onto site) dispersed inputs through relational connections, holding them in place, and making them count in distant places as new (and attributable) knowledge.

The discussion so far has explored the idea of knowledge circulation in terms of the distributed and distanced workings of actor networks. But the idea also has a literal meaning, involving the deliberate use of mobility as a means of maintaining the ‘potential for creating unexpected connections’ (Hargadon, 1998: 219). Increasingly, as Thrift (2000) notes, ‘new means of producing creativity and innovation are bound up with new geographies of circulation which are intended to produce situations in which creativity and innovation, can, quite literally, take place’ (p. 24). These are geographies supported by a rich and diversified infrastructure of global travel and communications, including rapid and frequent trains and flights for mass transit, meeting places and residential sites for those on the move, sophisticated logistics networks to keep freight and people on the move on a just-in-time basis, easy access to a variety of real-time and interactive communications’ media, and new possibilities for voice-and-visual contact at a distance.

Thrift provides three examples of such circulation. The first is the familiar ‘constant quartering of the globe by executive travellers’ (p. 24) to attend in person meetings where face-to-face contact permits brainstorming, sealing deals, checking credentials, renewing trust, inspiring passion. Such travel has become routine in business and knowledge transactions – an out of office activity no longer confined to meetings with local suppliers and customers or confidences in local clubs and associations. It covers aspects of ‘being there’ that are not easily achieved through remote interaction, but at the same time, it does not demand enduring face-to-face interaction and local embedding (in fact very many meetings are in neutral places). The meetings are one element in a continuum of relational interaction at a distance, over the wire, through past contact, based on reputation and recommendation, and so on. Their temporary duration and intensity – their increasing routinisation as a transactional mode – have allowed the spatial span of creative interaction to be stretched without loss of the intimacies normally associated with face-to-face interaction.

The second example cited by Thrift of circulation as a means of creativity is the ‘construction of office spaces which can promote creativity through carefully designed patterns of circulation’ (p. 26). Designing office spaces for informality, casual contact, breaking established communities and hierarchies, encouraging surprise encounters and unplanned socialisation has become an expensive but important tool in the management kit to engineer creativity. Layout has become a visual symbol of how serious companies are about encouraging creativity, and is increasingly used in business chat and in the media to rank high performance and innovative companies. One trend, for example, is

the replacement of offices by ‘hot desks’ that busy employees constantly on the move may book for a finite period. While this move has been driven in part by a desire to cut out wastage in the use of office space, it also aims to normalize circulation, exploit the possibilities of new desk partners and conversations and inculcate a sense of attachment to projects and broader corporate goals rather than to a particular office and its trappings of security and ownership. Another trend has been the creation of common spaces such as atria, gyms, café-offices, green spaces, streets and squares – all within a building – in order to encourage serendipitous contact and conversations away from the heat of the moment, as a means of circulating information, sparking new ideas, and developing new socialities.

Finally, Thrift highlights new possibilities opened up by advances in virtual communication. He notes the rise of Internet ‘thinking studios’ or ‘innovation exchanges’ which ‘promote knowledge exchange and sharing by bringing different actors together’ (p. 28). These are highly interactive ‘virtual clusters’ that involve a considerable transfer of virtual information over considerable distances. They are geared up for visual contact, memorisation and coding of past conversations, digitisation of data, drawings, jottings, ‘mood’ and ‘atmosphere’, sequencing of conversations, trust, commitment and enthusiasm for given projects, and so on. They act as virtual knowledge communities, enrolling knowledge workers at individual sites and workstations into a wider everyday net of highly creative relational interactions. There has been an explosion of virtual communities, communities that can no longer be seen as somehow less able than physically proximate communities. These communities have built up all sorts of routines and conventions, as well as organising structures (e.g. gatekeepers, web managers, orientation maps), that allow meaningful interaction and communication, sequence and memory, trust and compliance, and a whole series of other aspects of the ‘soft’ architecture of learning normally reserved for face-to-face communities. The upshot is that knowledge work has to be seen also as an immanent force with a virtual spatial structure.

A fourth literal example of circulating knowledge that can be added to the list relates to the increasingly transnational span and mobility of epistemic communities. We saw in paper 4 how these communities are crucial sources of emergent and radically new knowledge based on focused projects, and how, like communities of practice, they draw on a rich anthropology of human and non-human entanglements and relational practices to generate understanding, insight, and creativity. Many are distributed communities, with knowledge production dependent upon a considerable degree of international collaboration and exchange, manifest in a variety of spatial expressions of ‘being there’, local and global.

In molecular biology, for example, laboratory presence – hence localisation and located practices – is without doubt of central importance due to the nature of the work, which requires close, on-going experimental work with physical objects and complex instruments. As Knorr Cetina (1999: 86) summarises, the ‘many forms of intervention in material objects, and the laboratory protocols summarizing them, illustrate the object-oriented processing taking place’, which conveys the importance of ‘the continuous daily

interactions with material things, of the need to establish close relationships with the materials, and of the experience bench scientists can gain from them'. But, importantly, laboratories talk to each other and there is a considerable international flow of information and people between them. This is especially so with the rise of large and expensive ventures such as the Human Genome Project, which draws on experts, and laboratories scattered around the world. Thus, as Rabinow (1996: 24) notes, molecular biology 'has taken up the current conjuncture through an increased use of electronic means of communication, of data storage, of internationally coordinated projects like the human (and other organisms) genome projects. The circulation and coordination of knowledge has never been more rapid or more international'.

Bodily or physical presence is interwoven with circulation in epistemic communities. High-energy particle physics is another scientific field that is based on large-scale and complex mega-experiments. Much of the work centres around significant sites such as CERN in Switzerland, which house massive detectors and other spaces for high energy experiments; sites which gather scientists from around the world and which depend on strong local communitarian procedures. But there is more to this epistemic community. It is also global, but held together, as Knorr Cetina (1999: 160) marvels in the context of one mega-experiment: 'how is it possible to conduct an experiment with 100 (UA2), let alone 2,000 (ATLAS), participants over the course of twenty years? What organizational policies are needed to keep 200 physics institutes – located all over the world and representing virtually all major languages, national scientific systems, and cultures – focused on a common goal?' We will return to what these organizational policies are in the next paper when we discuss the management of distributed communities. Here all we wish to note is that 'distributed cognition' has involved building commonalities and a sense of the whole beyond the individual laboratory, through the constant exchange of information and people, frequent meetings, bonding at conferences, skeletal presentations that members from other teams can contribute to, and so on. In short, the increasingly intense circulation of knowledge.

Conclusion: Distanciation and Geographical Clusters

The thrust of our argument in this paper has been, to paraphrase Oinas and Malecki (2002: 103), that 'innovation systems are worked out differently in space; they exhibit different spatial configurations. They may originate in one place, but often they are spread beyond local, regional, and even national borders'. The everyday possibility of striking and maintaining distanciated links, the everyday possibility of action at a distance, the everyday possibility of relational ties over space, the everyday possibility of mobility and circulation, the everyday organization of distributed systems, make mockery of the idea that spatial proximity and 'being there' are one and the same. There are many spaces of relational proximity, which is why we should be wary of claims privileging the special powers of place in the production of that rare asset called tacit knowledge. The emphasis on relational proximity also forces a reconsideration of what is at work in those sites such as Silicon Valley or other Marshallian industrial districts where relational proximity is secured locally. These can be seen as spaces where the innovative thrust comes from the intertwining of communities (of engineers, entrepreneurs, financiers,

computing experts, advertisers, and so on). Thus the dense relations or ecology of interlinked communities act as the field of innovation and creative thrust, so that when a firm or venture fails, the ecology remains unthreatened, and able to push new projects, adjustments, and opportunities. The 'secret', thus, of local clusters may reside much more in the relational aspects of community (i.e. as one spatial form of knowing through communities) than on the balance between tacit and codified knowledge.

But, there is more at work in these clusters. We end this paper by illustrating, with the help of the most famous example – Silicon Valley - that knowledge work within clusters is dependent upon translocal connections and mobilities. Silicon Valley is commonly cited as a paradigmatic example of the powers of local economies of agglomeration and association. However, in a challenging paper, Saxenian and Hsu (2001) show that a transnational technical community of US-educated Taiwanese engineers is increasingly responsible for part of the technical excellence of Silicon Valley, where, by 1999, 17% of the companies started in the region since 1980 were run by CEOs from Chinese backgrounds, with the majority from Taiwan. On the back of a history of Taiwanese students travelling to Silicon Valley for graduate courses, setting up firms in the Valley, returning to start up new businesses, owning businesses across the Pacific, travelling regularly to both regions and treating them both as the 'home base', and developing a strong and well-supported diaspora network, a 'community of Taiwanese returnees, 'astronauts' and US-based engineers has become the bridge between Silicon Valley and Hsinchu' (p.911). Here are some telling facts:

Silicon Valley's Taiwanese engineers and scientists continue [to] travel to Taiwan regularly (7.3% travel to Taiwan more than five times a year for business purposes, 22% travel between two and four times a year). The great majority (85.3%) have friends and colleagues who have returned to Taiwan to work or start a company, with 15.8% reporting more than 10. They regularly exchange information with friends and colleagues in Taiwan about technology and about job opportunities in both locations. More than one third (38.9%) have helped to arrange business contacts in Taiwan, one quarter of them (24%) have served as advisors and consultants for Taiwanese companies, and one fifth (19.2%) have invested their own money in start-ups or venture funds in Taiwan (Saxenian and Hsu, 2001: 916).

An elaborate transnational structure of business links, family and friendship ties, shared technical and tacit know-how, venture capital, ethnic social networks, and business and cultural associations, bridges the two regions. Consequently, Saxenian and Hsu note that 'just as the social structures and institutions *within* these regions encourage entrepreneurship and learning at the regional level, so the creation of a transnational technical community facilitates collaborations between individuals and producers in the two regions' (p. 916). The consequence is that 'what was once a one-way flow of technology and skill from the United States to Taiwan has become a two-way thoroughfare allowing producers [in] both regions [to] collaborate to enhance distinctive but complementary strengths of these comparably decentralized industrial systems' (p.

911). The distanced network is responsible for knowledge generation and excellence in both technopoles.

In citing this example, our intention is not to diminish the salience of local geographies in supporting economic dynamism and knowledge formation. Instead, it is to show that the relationship between space and economy is always a variegated relationship, based on the simultaneous mobilisation of many geographies of reach and connectivity.