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Tacit Knowledge, Innovation and Economic Geography

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Summary. The aim of this paper is to outline the importance of tacit knowledge in the innovation process and to highlight the way that geographical location not only influences the relationship between knowledge and innovative activity, but also affects the way that such interaction influences the geography of innovation and economic activity. After a discussion about the nature of knowledge, the paper explores the relationship that exists between knowledge and geography. The paper then reviews, using as an analytical lens, the growing body of literature on knowledge spillovers which affirm the importance of geography. However, the discussion then seeks to outline some crucial gaps that remain in our conceptualisation of the knowledge spillover and transfer process. The paper then highlights the neglected role of knowledge demand and consumption in a spatial context, before concluding with a review of areas for future research.

1. Introduction

The objective of this paper is to outline the importance of tacit knowledge in the innovation process and to highlight the way that geographical location not only influences the relationship between knowledge and innovative activity, but also affects the way that such interaction influences the geography of innovation and economic activity. However, why is the study of knowledge, in particular tacit knowledge, important to economic geography? Knowledge is crucial in helping to create innovation which in turn stimulates economic growth and development. It also plays a more specific role in establishing and sustaining the long-term capabilities and performance of firms and organisations and in enhancing the success and well-being of individuals and communities. It is understandable, therefore, that interest should focus on how geography influences knowledge activity and how geography in turn may be shaped by such processes.

The paper begins by exploring the still-contested definition and meaning of knowledge, before highlighting why geography is important when considering knowledge processes and activity. To provide a lens onto some of these issues, the paper then critically examines the growing body of economic literature relating to knowledge spillovers. The discussion then highlights crucial gaps in our conceptualisation of the knowledge spillover and transfer process. The role of the demand for, and consumption of, knowledge is then explored before the paper concludes with some reflections on the nature of tacit knowledge in the context of economic geography and areas for future research.

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2. The Meaning and Importance of Knowledge

Knowledge can be defined as a dynamic framework or structure from which information can be stored, processed and understood. Knowledge, therefore, has a relational characteristic, involving a 'knowing self' and an event or an entity (Plotkin, 1994, p. 40). Knowledge also requires a memory—an enduring brain state that must exist to allow the bridging of the time-gap between events that have occurred and any claim to know about them (although memory about events in the past in turn undergoes change and therefore forms an unconscious, altering form of knowing; Plotkin, 1994, p. 8). Above all, knowing is an active process that is mediated, situated, provisional, pragmatic and contested (Blackler, 1995).

Knowledge is therefore associated with a process that involves cognitive structures which can assimilate information and put it into a wider context, allowing actions to be undertaken from it. Thus knowledge in turn combines the process of learning (Polanyi, 1958, p. 369). The take-up of learned behaviour and procedures is a critical element within knowledge acquisition, both in terms of capturing and transferring it from the individual to the organisational level (Kim, 1993) and also in more widely diffusing such competence throughout the whole organisation (Urlich *et al.*, 1993). To be able to innovate, invent and discover, involves using existing knowledge, but often also requires generating and acquiring new knowledge and this centrally involves learning. Innovation also involves sharing learned knowledge. This mutual exchange of knowledge and shared learning means that knowledge is intrinsically a socially constructed process (Berger and Luckmann, 1966).

There have been various attempts to identify and classify different types of knowledge, but an early and seminal distinction has been made by Michael Polanyi (1958, 1961, 1962, 1966, 1967) who distinguished between explicit (or codified) knowledge and tacit knowledge. The difference between these two broad types of knowledge is linked to the degree of formalisation and the requirement of presence in knowledge formation. Explicit or codified knowledge involves know-how that is transmittable in formal, systematic language and does not require direct experience of the knowledge that is being acquired and it can be transferred in such formats as a blueprint or operating manual.[1] By contrast, tacit knowledge cannot be communicated in any direct or codified way. Tacit knowledge concerns direct experience that is not codifiable via artefacts. Thus, it represents disembodied know-how that is acquired via the informal take-up of learned behaviour and procedures. Indeed, some tacit knowing is associated with learning without awareness—a process termed as 'subception' by Polyani (1966). Tacit knowledge can also be associated with scientific intuition (see, for example, Ziman, 1978, p. 103) and the development of craft knowledge within scientific disciplines (Delamont and Atkinson, 2001).

Elsewhere, Polyani (1962) sums up tacit knowing as an act of 'indwelling', the process of assimilating to ourselves things from outside. However, it also involves, more innate values, such as skills. In addition, it is generally accepted that tacit know-how cannot be directly or easily transmitted, as knowledge and task performance are individual and specific and involve the acquirer making changes to existing behaviour. However, the degree of tacitness does vary (Howells, 1996). Within the range of tacit knowledge itself, the less explicit and codified is the tacit know-how, the more difficult it is for individuals and firms to assimilate it (Cohen and Levinthal, 1990, p. 135; see also Nelson and Winter, 1982). 'Learning by doing' (Arrow, 1962), 'learning by using' (Rosenberg, 1982) and 'learning to learn' (Ellis, 1965; Estes, 1970; Argyris and Schon, 1978; Stigilitz, 1987) are seen as critical elements within tacit knowledge acquisition.

It has been argued elsewhere (Howells, 2000) that much of Michael Polanyi's work on knowledge has been misinterpreted. One

such example is the crude bi-polar dichotomy that is drawn between tacit and codified knowledge. This woefully misrepresents Polanyi's own thinking: Polanyi was at pains to stress that explicit and tacit knowledge were not divided but should be seen rather as a continuum between wholly explicit knowledge and a wholly tacit form of knowledge. Above all, Polanyi saw that explicit knowledge indeed required tacit knowledge for its interpretation (Polanyi, 1966, p. 7). This bi-polar distinction has been carried through into further analyses which suggest that: (a) the codification and commodification of knowledge are intensifying and ensuring its more rapid and low-cost diffusion; and, (b) you can clearly separate out knowledge transfer into a local-tacit and global-codified matrix. Both Allen (2000) and Roberts (2001) have recently argued how potentially misleading and spurious these characterisations are.

Michael Polanyi has also been accused of taking an excessive cognitive approach to his definition of knowledge which tends to bring the understanding of knowledge down to a personal, 'atomistic' level which makes little allowance for context and institutional setting. Although Polanyi's work does have a number of difficulties and inconsistencies, his cognitive approach is strongly imbued (or even dominated) by a wider philosophical appreciation of knowledge and, indeed, Gelwick (1977) sees this as his main contribution to our thinking about knowledge.[2] Moreover, Polanyi's belief that knowledge can only be truly personal knowledge, does not diminish the importance of context—rather, indeed, it heightens it. Thus, although stressing the individual realm and its cognitive base, Polanyi also acknowledged that such cognitive frameworks were strongly shaped by external social, organisational and economic contexts. Indeed, he was one of the first to recognise the 'communal' and institutional aspects of knowledge formation (in the context of the role of scientific communities) which was subsequently taken up by researchers analysing the role of knowledge-practitioners and communities. Indeed, Polanyi acknowledges the key negative impact that institutional settings and context could have on knowledge creativity.

3. Knowledge and its Geographical Context

From the definition and description of knowledge outlined above and its specific interpretation here, how does geography influence, and in turn be influenced by, knowledge and knowledge activity? Basically, why is geography important to our understanding about knowledge? It is argued here that there are five ways in which geography impinges on knowledge and knowledge activity and which has a profound influence on it. They are

(1) Knowledge is centred on a knowing self, an individual, and this 'knowing self' is influenced in its human *development* by its cognitive, social, cultural and economic circumstances which in turn are influenced by its geographical environment; namely, by place.[3]
(2) Associated with this, this development of an individual's knowledge-set is influenced by human *interaction*, again shaped by place and constrained by distance.
(3) The on-going development of an individual's knowledge-set in turn requires externally acquired *information*, both in codified and in more tacit forms (associated with human interaction noted above), which is spatially constrained by distance in terms of scanning costs and acquisition barriers.
(4) Although an individual's knowledge-base depends on externally acquired information, information is also taken up through *learning*, which is by its nature situated within a geographical, social and economic context. Much of this learning is done jointly with others—not only in educational establishments, but also through the on-going process of work which is for the most part site- and location-specific (for example, on the factory shopfloor or in the research laboratory).

(5) Lastly, all the information taken up by an individual has to be filtered and *interpreted*. Even highly 'digestible' codified information requires interpretation using tacit know-how, based on past experience and shaped by geography.

Distance, proximity and geography all count here, although the importance of this geography will vary depending on what type of knowledge and the context of its generation and transfer. For economic geography (and indeed for corporate management), although individual knowledge generation, transfer (and consumption; see later) remain important, the real challenge is how these individual knowledge-sets interact, configured and harnessed within a wider organisational realm to create a common knowledge context (Howells, 2000, p. 55).

The real confusion and problems set in when discussing knowledge and geography when three elements are introduced. The first is when firms and organisations are attributed with having a knowing self and possessing, in a direct sense, 'knowledge'. Trying to attribute a firm as directly possessing knowledge is misleading. Rather, firms—via managers and employees—can harness knowledge through their staff, who organise routines which utilise corporate information and databases and who help to create new knowledge, sharing it with others. The second is when knowledge is said to 'flow' between individuals (or still less, firms), when in fact information is shared and it is this sharing which leads to a change in the knowledge-base of an individual or group of individuals.[4] Although extensibly all such individuals will obtain the same information, how an individual filters and interprets that information will remain subtly different due to a person's ability to learn new things based on an individual's former experience. On this basis, the new knowledge based on this information will be different between each person. Thirdly, the impact of 'geographical proximity' is not always (or indeed usually) direct—its influence is often indirect, subtle and varied. Geographical space influences cultural, social and psychological space through which knowledge is generated and imparted. Hence 'relational proximity' associated with the formation of organisational routines and social practices may indeed in many instances be more important than geographical proximity in a direct sense (Amin and Cohendat, 1999, 2000), but geography has a profound impact on these very routines and practices within organisations (see, for example, Allen, 1977) and therefore its underlying *indirect* importance remains. Thus, for example, interpersonal distance—which has a strong influence on task-related interaction within organisations—is in turn shaped by physical distance and its constraints.

4. Interpretations of Localised Knowledge: Knowledge Spillovers

How has knowledge activity been analysed and empirically mapped in a geographical context? Geographers have largely avoided undertaking large-scale detailed empirical analysis of what might be termed the geography of knowledge, although, as will be shown, this is perhaps not surprising given the problems of trying to measure knowledge 'on the ground' and the often heroic assumptions that have been used in undertaking such analysis. However, economists have had a growing interest in the geography of knowledge, in the form of studying spatial dimensions to knowledge spillovers and a burgeoning literature has developed associated with this field of research. These studies will be reviewed as a way of assessing (however imperfectly): whether geography still matters in relation to knowledge transfer; and, whether such studies provide insights that others can usefully take up and develop. Lastly, and not unexpectedly given the complexity of knowledge processes, such studies also help to highlight and yield up major gaps in our conceptual analysis of knowledge and this will form a basis for discussion in the remainder of the paper.

There has been a growing number of studies which have sought to analyse the

presence and significance of localised knowledge spillovers. The process whereby knowledge spills over and is appropriated by other firms has been largely assumed in traditional economic literature as an almost costless and frictionless process. Where knowledge has been considered in this tradition, it has been treated as a public good that is easily transferred between people and organisations. Thus, knowledge was seen as a public good because it was seen as being impossible for its creator to prevent it being used by economic agents who do not pay anything in exchange for it (Saviotti, 1998). Knowledge becomes generally available through various means including publications, patents and informal sharing and this non-excludability of knowledge is associated with such knowledge spillover effects.

A series of spillover studies have examined the localised relationships in terms of patent activity, industry, labour mobility and university R&D levels and innovation rates (see, for example, Jaffe, 1989; Acs *et al.*, 1992; Jaffe *et al.*, 1993; Feldman, 1994, 1999; Audretsch and Feldman, 1996; Anselin *et al.*, 1997; Audretsch, 1998). There are a number of ways in which these knowledge spillover studies can be grouped together. Perhaps the most direct are the actual ways they see knowledge being transferred in the spillover process or the relationships involved with such a process.

An early focus of such spillover studies has been on examining linkages associated with codified forms of knowledge. Thus, Jaffe's (1989) study analysed corporate patent activity at the state level and found that it was influenced by university research spending, after controlling for corporate R&D. Similarly, Jaffe *et al.* (1993) examine the localised pattern of patent citations (both from corporate and university patent citations) to suggest that local knowledge spillovers exist. Almedia and Kogut (1997) also used patent citations to study the semiconductor industry in the US and found that there were clear localisation effects in terms of citations. Jaffe and Trajtenberg (1999) take a wider view by studying international knowledge flows using patent citations and confirm the localisation of knowledge flows.

These studies have therefore focused on the mapping of codified 'knowledge' in the form of patents and patent citations, but there have been other approaches to analysing knowledge spillovers. The second approach has been to map the movement of people on the basis that knowledge moves with them. A study by Audretsch and Stephan (1996, p. 650) that analysed links between university scientists and biotechnology firms, found that spatial proximity matters in shaping these links, although not on an overwhelming basis. Zucker and Darby (1996) focus on 'star scientists' (defined as highly productive individuals who discovered a major scientific breakthrough in biotechnology) and see their geographical concentrations being linked to the localisation of new biotech entities (NBEs; see also Zucker *et al.*, 1997). Almedia and Kogut (1997) chart the interfirm mobility of star patent-holders in the semiconductor industry and similarly conclude that the transfer of ideas is associated with mobility patterns between firms and that this is a further reflection of knowledge spillovers being geographically confined.

The third stream of analysis has been based on the assumption that knowledge can be embodied in goods and that knowledge 'flows' can therefore be mapped, at least at the international level, using trade patterns (Feldman, 1999, p. 13).[5] Trade is seen as being associated with knowledge spillovers;[6] and both Park (1995) and Coe and Helpman (1995) use trade patterns to identify international R&D spillovers. Branstetter (1996) manages to consider intranational knowledge spillovers on this basis, but there remain severe conceptual and methodological limitations of mapping knowledge spillovers using this approach. The biggest issue here is the notion that knowledge can be embodied in goods.

A further element in these knowledge spillovers has been simply to analyse knowledge-intensive industries and see how concentrated they are (and also assess in performance terms whether they are more

innovative). This is based on the assumption, and implicit in the knowledge production function model, that such industries are concentrated, at least in part, because of knowledge spillovers (but also because knowledge-generating inputs are also greater). Audretsch and Feldman (1996), following on from Krugman's (1991) work, found that industries which were more knowledge-intensive (measured by industry R&D, academic research and skilled labour) were also more spatially concentrated. This, they observed, reaffirmed the importance and prevalence of knowledge spillovers particularly in these knowledge-intensive industries, although they acknowledged that this depended on the assumption that "knowledge externalities are more prevalent in industries where new economic knowledge plays a greater role" (Audretsch and Feldman, 1996, p. 639).

Linked to observing these patterns of concentration has been the attempt to assess their impact on innovative performance and the output effects of knowledge spillovers. Thus, Feldman (1994) concluded from her study that knowledge spillover occurs because geographical regions with greater amounts of knowledge-generating inputs, measured by using patent counts, produce more innovation. Adams and Jaffe (1996), in their study of the effect of knowledge spillovers on the productivity of firm R&D, found that spatial proximity did play an important role in most instances. In turn, Acs *et al.* (1999, p. 75) discovered that university R&D centres across the US had a statistically significant impact on employment in four high-technology sectors.

5. Uncovering Localised Knowledge Transfer and Sharing

What can be learned from these knowledge spillover studies? First, these studies are valuable in that they do much to suggest the power and influence of geography in shaping knowledge interactions. Geography still counts in terms of knowledge activity, a theme echoed recently by Morgan (2001). Secondly, and perhaps more surprising given the assumed spatially unconstrained nature of codified knowledge, is that both measures of tacit *and* codified knowledge suggest localised patterns of interaction. This suggests that tacit knowledge, situation and locational context do play a significant role in the use and spread of *codified* knowledge. Thus, although codified knowledge may be more ubiquitous and accessible, its interpretation and assimilation are still influenced by geography. Lastly, such studies have shown a variety of different attempts at measuring knowledge for locational mapping. Thus, they acknowledge that there are a whole variety of potential parameters involved in measuring knowledge; using one method will only provide a highly partial view of knowledge activity.

However, there are a number of limitations associated with these studies. One is the set of assumptions they make about knowledge. Much of the analysis concentrates on public–private and private–private spillovers, and in terms of 'knowledge' as 'flowing' in codified or embodied formats. Jaffe's (1989) original study sees 'public' knowledge, in the form of university research, being appropriated by private firms, as underpinning these knowledge spillovers. Even where university scientists and their links (such as company scientists holding university chairs), are studied, their actual contact patterns are not examined. Indeed, most of the metrics *imply* the imparting of knowledge, but do not actually measure it. Above all, real-life investigations of micro-level, knowledge transfer and sharing are not undertaken. This indeed is acknowledged by Feldman who notes

> One limitation … is conceptual because there is no understanding of the way in which spillovers occur and are realized at the geographic level (Feldman, 1999, p. 8).

How might these knowledge spillovers actually occur? The focus of many of the knowledge spillover studies has been on intended and codified forms of 'spillover'.[7] It is important here to recognise that although many spillover effects may be formally in-

tended and codified in nature, many are not and remain unintended, tacit and informal in nature. Intended and codified forms of spillover have been already enumerated by the studies. They include research contracts and collaborations with other firms (such as suppliers and customers), universities and public research laboratories, as well as formalised institutional links. On an employee basis, these include industry-funded university chairs, industrial scientists having secondments or part-time placements in university laboratories, university students and staff having placements, directorships or part-time involvement in private firms.[8]

On a wider institutional level, universities may be involved in firm spin-offs and hold venture capital in such operations. Knowledge intermediaries in the form of specialist service design, research or engineering firms and consultancy companies also form significant mechanisms aiding knowledge transfer. Intended but largely informal knowledge spillovers could be in the form of local or national membership of learned societies or industry associations or regional agencies, as well as attendance at conferences and workshops. Such mechanisms for knowledge transfer could be partially reflected in more codified forms of information, such as patent citation. At best, however, they describe *conduits of knowledge transfer* rather the process of knowledge transfer itself.

Unintended, informal knowledge spillovers are much harder to measure and therefore have been largely neglected in knowledge spillovers studies, although acknowledged as being part of the wider spillover process. These unintended transfers, where the owners of such knowledge cannot prevent others from making use of it (Grossman and Helpman, 1991, pp. 15–16), include: departure of key scientists and engineers (including poaching of key staff); informal know-how sharing (von Hippel, 1987, 1990); unintended signalling of key information at conferences and workshops; membership of 'invisible colleges' and research schools (Olesko, 1993, p. 16) and professional links associated with specific 'communities of practice' (Lave and Wenger, 1991; Barley, 1996) related to membership of professional associations or informal groupings (see, for example, Sørensen and Levold, 1992); and unintended leakage by consultants or design practices of information picked up from one client and applied to others.

However, there are key aspects of knowledge transfer that have also been largely excluded or underplayed from spillover analysis. These can be grouped under two broad areas: interfirm and intrafirm issues. In terms of interfirm issues, these cover: sectoral differences in spillover patterns; the role of knowledge intermediaries; and, institutional frameworks. In relation to intrafirm issues, these relate to: intrafirm knowledge transfers; scanning and the cost of acquiring information; and, the role of learning in knowledge formation and transfer. Obviously some of the issues, such as learning, cover both levels of analysis, but this framework provides an initial entry-point to the discussion.

In terms of sectoral issues, this is indeed one area which knowledge spillover studies have actually highlighted as an area for further study. Thus, Adams and Jaffe (1996) found that spatial proximity did play an important role for chemicals R&D productivity, but for pharmaceutical R&D locational proximity had very much less of effect on R&D efficiency. Clearly this depends on the nature of the industries involved. Thus, if one accepts that codified knowledge is less geographically bounded, then industries which are more scientific in nature and depend more on codification and the transmission of information via codified 'knowledge', such as scientific papers and patents, may display knowledge spillovers that are less localised in nature. The pharmaceutical industry would be an example of just such an industry. By contrast, other sectors, such as certain types of engineering, where learning-by-doing and tacit knowledge are more important, would display more localised spillover effects.

In relation to what might be collectively

termed as 'knowledge intermediaries', there has been a growing acknowledgement in the geographical literature of the importance of specialist business service providers, consultants, contract research and testing organisations led by studies by MacPherson (1988, 1991) and Bryson *et al.* (1993; see also Bryson, 1997). Indeed, Wise (1949, p. 63) highlights the role of factors and merchants in the jewellery and gun quarters of Birmingham as providing a similar embryonic supporting role here. The role of specialist business service providers or technology-related knowledge-intensive business service (t-KIBS) firms has been shown by these studies to be an important catalyst for knowledge transfer and local innovative performance.

The importance of institutions in regional development and economic performance has been highlighted in a number of studies and they too have a specific role with knowledge transfer (see, for example, Morgan, 1997; Cooke and Morgan, 1998). Scotland, for example, in the late 17th century had an institutional scientific and innovation infrastructure which did much to facilitate the flow of ideas and led to the prominence of Scotland in terms of its scientific and medical base (Howells, 1999, p. 68). Thus institutions are important in helping to shape the local contexts for formal and informal knowledge-sharing and in providing support infrastructures to utilise knowledge within the innovation process. In this way, they develop the associational capacity of the system (Cooke and Morgan, 1998) with regard to knowledge.

Associated with the external patterns of knowledge transfer are the internal knowledge transfers within the firm. The ability of firms to transfer information knowledge internally across space is, *ceteris paribus*, much easier—and especially if it occurs within a research or other group. Research by Allen (1977, p. 241) has confirmed that, for example, R&D information flows show far fewer distance decay effects if they involve intragroup communication, associated with a clear organisational bond. Multinational and multisite firms are important agents in transferring research and knowledge (Blanc and Sierra, 1999). Information and knowledge obtained in one location can be transferred to another site within the firm, overcoming the often information- and knowledge-poor environments its branch plant, for example, may operate (but equally create a technological 'isolation effect' where such a plant has little information and knowledge interaction with its local environment; Howells, 1985). However, even intrafirm transfers of knowledge are influenced by geography and do not remain unproblematic (Oujian and Carne, 1987).

Another intrafirm element here is the role of scanning and the cost of acquiring information and knowledge by firms. Firm-level contexts are very important in determining the nature and success of firms scanning their external environment (Taylor, 1975). Thus the ability of firms to scan their knowledge environments is strongly influenced by the size of the firm, its past experiences, its research and knowledge capacity and indeed its location. Some firms are highly limited in their capacity to scan and acquire knowledge (linked to the cost of scanning and resources available to them to do this). Indeed, Antonelli (2000, p. 539) has recently highlighted the role of communication costs in acquiring technological knowledge and has outlined the different information characteristics of local environments in facilitating information exchange (see also Warf, 1995).

Lastly, learning has an important interorganisational dimension and this is obviously important in how knowledge can be shared amongst firms (Maskell and Malmberg, 1999), although much key knowledge is generated, learned and shared *in situ* within the firm. Joint learning and learning contexts within the firm help to create the formation of shared routines between workers which in turn helps the sharing of knowledge and the establishment of an organisational 'memory' (Ackerman and Halverson, 2000) which guides future interpretation of events. Shared routines and patterns of working, and the socialisation of this process, help to create important environments for learning to take

place and then help to form common knowledge contexts between workers in the firm (Howells, 2000, p. 55). Learning is intimately tied up with the generation, but also with the sharing of knowledge between individuals within the workplace (Morgan, 2001).

6. Cities and Regions and the Consumption of Knowledge

Most of the above analysis has been about the transfer and sharing of knowledge; little has been discussed in relation to its generation and production or in particular its consumption. There have been a whole series of geographical studies on the location of R&D and other related technical activities associated with what may be termed the 'production' of knowledge (Gertler, 2001). These supply issues are important to understand since these will obviously influence the density and pattern of knowledge interaction.

However, there has been little or no acknowledgement of the *demand* for and consumption of knowledge.[9] Thus virtually all of the knowledge spillover studies fail to acknowledge the role of knowledge demand and consumption and the ability (and cost) of firms to absorb such knowledge (Cohen and Levinthal, 1990), reflecting in part no doubt the underlying traditional 'public good' notion of knowledge and its costless characteristics in a number of these studies. On this basis, demand in a sense need not be considered, since knowledge would somehow permeate to those who needed it.

In terms of markets for knowledge, where knowledge is involved, directly or indirectly, in some transaction process, there are a number of mechanisms. First, for codified knowledge where an outcome is already known, *a posteriori*, this could be purchased 'off the shelf' via publications or through license agreements. Secondly, *a priori*, knowledge could be obtained through research agreements, or contract R&D (from design and engineering companies, or universities or public research laboratories) although this would involve some delay and uncertainty of outcomes (if the research failed or a solution was not found). Thirdly, knowledge components could be purchased through the direct recruitment of key scientists, designers and engineers or their temporary hire.

It should be recognised, however, that much of the demand for knowledge is in non-market terms. Thus, for many other types of knowledge the exchange is via non-market mechanisms—through, for example, bartering and informal know-how trading (von Hippel, 1987; Knoedler, 1993) or through reciprocal knowledge-sharing via joint-venture operations. Above all, there are no clear market mechanisms which facilitate the transfer of tacit knowledge directly (Malecki, 2000, p. 108). For tacit knowledge, however, the real problem goes beyond its demand, back to the initial identification and articulation of the knowledge to be 'demanded'. Since tacit knowledge is essentially by its definition difficult to articulate this makes its demand and consumption such a difficult process. Indeed, if we accept Polanyi's concept of tacit knowledge, there will be elements of our knowledge-base that not only will we find difficult to articulate but also that we will not know that we even possess. Uncovering and identifying these often-hidden reserves of tacit knowledge and being able to understand and articulate what is required by individuals and firms is an important, but neglected, part of knowledge activity.

What role does geography play in these demand-side issues in knowledge activity? Allan Pred has indeed highlighted the geographical aspect of demand in relation to patterns of inventive activity;[10] and a key function for major cities and core regions is that they are places where there is strong, market- and non-market-related, demand for knowledge but perhaps more especially where tacit knowledge can be more readily articulated by others. Thus the articulation and consumption of new knowledge may be especially important in such places that are also likely to have a concentration of 'early adopters' of knowledge and innovation which firms are keen to tap into and which

makes them important theatres of both market and non-market knowledge.

The spatial pattern of knowledge demand can also play a more negative role in the pattern and scale of knowledge spillovers. Thus low demand for knowledge in its local originating area may mean that it has to have a much wider knowledge-spillovers 'footprint' or indeed that it gets lost (or undiscovered; see below) or ignored and thereby hardly makes a 'footprint' or impact at all. Lastly, there is the question of who benefits from consumption in terms of R&D productivity and overall competitive performance. Obviously, the absorptive capacity of firms is important here when considering who *benefits* from knowledge; however, again there is the issue of the transferability of knowledge. Because many firms in peripheral regions have low absorptive capacities, their ability to benefit from external knowledge remains limited. However, sometimes the knowledge remains too complex and tacit to be absorbed—however hard a firm tries. Thus, some firms remain supremely confident that other companies will have no capacity to absorb or utilise the particular knowledge-sets they hold. Thus, Leonard and Sensiper (1998, p. 121) highlight the confidence that some firms have in the inability of their rivals to copy company-held tacit knowledge and quote the examples of Chaparral Steel and Oticon actually inviting competitors to visit and observe their processes, convinced that no one could imitate their knowledge-base.

7. Localised Knowledge: Reflections and Conclusions

Knowledge spillover studies have confirmed that knowledge transfer is spatially constrained, although they provide little, if any, analysis of the mechanisms of knowledge transfer and sharing. What is interesting here is that, although many of the studies only used codified 'knowledge' as measures in the knowledge spillover process, they still found a distinct distance-decay effect in 'knowledge' transfer. This indicates that the notion that codifying knowledge somehow frees it from its geographical shackles ('ubiquitification'; Maskell and Malmberg, 1999; see also Nonaka and Takeuchi, 1995a, 1995b) needs reinterpretation.

In this respect, time can provide a crucial dimension in this discussion and is something that seems to get lost in such a dynamic process of knowledge formation and sharing. Thus a study by Feldman (1999, p. 10) suggests that codified knowledge (using patent citations) may be localised, but that this localisation effect may fade more rapidly (i.e. after the first year following the patent). However, even this relatively short period of localisation may be important as, in a number of key sectors (such as electronics and optics) there is such rapid obsolescence that even after this short period of localisation, such knowledge would hold little value, once it became more widespread. At least in the important (and valuable) early stages of its life, therefore, codified knowledge does not remain costless in its discovery and use, and the social and economic context of its use remains crucial.[11] Also, its interpretation still requires a tacit component (Polanyi, 1958). All aspects of this process remain influenced by geography.

Time, or rather timing, can also play a role in determining *when* knowledge is shared. Thus von Hippel (1987) quotes the example of aerospace firms who desist from know-how trading in anticipation of their direct competition for a particular defence contract, but resume knowledge exchange once the award is made. Time, decay and loss are therefore crucial elements in knowledge transfer. The value and utility of knowledge can decay over time, but it can also be lost or simply forgotten. Thus, in studies of knowledge transfer and sharing, aspects of the spreading of knowledge through spillover are important, but the decay or paracme of knowledge can be equally important in influencing the geography of innovation and growth.

Knowledge spillover studies have therefore proved valuable in highlighting that the knowledge spillovers process remains localised and that this holds true, at least initially, for codified knowledge. What such studies do not provide are insights into the

process of knowledge transfer and sharing which remains a 'black box' in terms of our conceptual understanding. Above all, tacit knowledge, although acknowledged, remains unexplored. The notion that tacit knowledge is all about individuals and that charting the movement of individuals within organisations indicates something about tacit knowledge transfer, as some knowledge spillover studies have done, is valid, but still goes little way towards uncovering the specifics—'what, when and how'—of such transfers. This is not to suggest that research into studying the spatial transfer of knowledge will be easy. In many cases, surrogate indicators will have to be used. However, at present, most work depends on oft-repeated assumptions of what is supposed to happen under mainly normative conditions.

Two further issues need highlighting in any discussion of knowledge and geography: one that has already been discussed; one that has not. The first relates to the demand for, and consumption of, knowledge and how geography shapes this process. Analysis so far has concentrated on supply-side issues and the transfer process; very little is known about the way knowledge is demanded and the consumption process and the take-up of knowledge. The second issue is the power dimension, which is strangely ignored in studies of knowledge.[12] As with all relationships, the process of transferring and utilising knowledge is shaped by issues of asymmetries in power, both in relation to socially bonded knowledge (Harvey, 1999) and in terms of interfirm and interorganisational knowledge relationships. This omission needs to be rectified if we are fully to understand the process of knowledge formulation and exchange.

Lastly, we should be careful about the particularities of geography. Virtually all the empirical studies of knowledge spillovers have explored the US context which will be, not unexpectedly, influenced by the 'national systems of cities' (Thompson, 1972; and the resultant information flows: Pred, 1972) and regions in North America and the nature and pattern of infrastructure in place there (Kellerman, 1984). There will undoubtedly be differences—some major, some subtle—in how knowledge is transferred in other countries and these need to be explored.

Notes

1. What Polanyi (1958, pp. 69–131) originally described as 'articulated' knowing; although articulation and explicitness are not directly equivalent.
2. Including his criticism of scientific objectivism and logical positivism; thus, in Polanyi's (1958, pp. 27–30) view there can be no purely factual statements.
3. An alternative word to 'influenced' is 'conditioned', but this implies a stronger deterministic flavour.
4. I indeed own up to this fault of misconceived thinking in an earlier paper (Howells, 1996).
5. Indeed, knowledge embodied in capital goods was the main way that economists studied knowledge (Saviotti, 1998, p. 843).
6. Although some of the studies quoted by Feldman (1999) relate more specifically to R&D rather than knowledge spillovers.
7. Although the word 'spillover' suggests a process which is not under some formal control.
8. The placement of university students and staff is formalised in the UK via the Teaching Company Scheme.
9. The word 'demand' is used in a wide sense here and not just in terms of payment for knowledge or some kind of formal arrangement.
10. Thus Pred noted

    > Inventive activity is, to a considerable degree, a function of unique supply-and-demand conditions that prevail in the cities of an industrializing economy such as that of the United States between 1860 and the early twentieth century. More precisely, many technological advances in the late nineteenth century were reliant upon a demand for inventions (Pred, 1966, p. 9).

11. As Granovetter (1985, p. 486) stresses, actors do not behave or decide as 'atoms' outside a social context.
12. Particularly given the Foucauldian formulae that knowledge equals power and power equals knowledge (Foucault, 1980, pp 93–94).

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