TERRITORIAL CLUSTERING AND HIGH-TECHNOLOGY INNOVATION: FROM INDUSTRIAL DISTRICTS TO INNOVATIVE MILIEUX

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Abstract

This paper reviews recent attempts to conceptualise and investigate the relationship between geographical proximity and innovative firm behaviour. Special attention is given to concepts of 'industrial district' and 'innovative milieu' and to the literatures in which they appear. This focus serves to identify important areas of consensus, underlying trends in thought and the main issues which stand in need of further investigation. User-producer and incubator-type innovation are distinguished and it is argued that the main advantage of the milieux literature is that it incorporates both types of innovation and, in so doing, provides a richer account of innovation, learning and the means by which these are encouraged by geographical proximity.

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1. Introduction

The "resurgence of regional economies, and of territorial specialisation in an age of increasing ease in transportation and communication of inputs and outputs" is perhaps the major phenomenon in need of explanation in economic geography (Storper, 1995). This phenomenon is especially surprising when one notes that clustering is particularly strong in the case of firms in high-technology, information-intensive sectors, sectors which one might expect, given the enormous recent developments in the new information technologies, to be the least sensitive to the need for geographical proximity. In attempting to explain these phenomena, attention has shifted away from individual firms to the productive system[1] within which firms operate, with particular emphasis being given to the region-specific qualities of the linkages that exist between firms. This movement has not, however, been a unified or systematic one. As a result, there now exists a relative plethora of new terminology including terms such as 'industrial district', 'technological district', 'technology district', 'technological complex', 'innovative milieu', 'nexus of untraded interdependencies', and so on, and it is not clear to what extent these terms, or the literatures giving rise to them, share commonalities either at the substantive or the methodological level.

This paper is mainly concerned with two of the above terms, namely the 'industrial district' and the 'innovative milieu'. Attention is restricted to these two, in part, to avoid repetition (given the substantial overlap between the terms), but more importantly because a direct focus upon these two most clearly brings out a number of trends and shifts in focus discernible throughout the wider literatures. The first section provides a brief overview of the origins, context for

rediscovery and recent development of the concept of an 'industrial district'. This is followed by a discussion of the 'innovative milieu', the literature giving rise to it and its relationship to the industrial district. It is argued that the distinctions between these terms are best understood in terms of the types of innovation involved. It is also argued that the literature concerned with innovative milieux has the advantage of being more general (and so more widely applicable) whilst, at the same time, focuses attention upon processes of learning which are relatively undeveloped in the industrial district literature.

2. From Marshallian to Italian (NEC) Industrial Districts

Marshall's ideas about industrial districts are set within his more general discussion of industrial organisation. Here, Smith's notion of a division of labour is combined with a form of Darwinian evolutionary theory (Marshall 1947: Book IV, Ch VIII and 1923: Ch IX). A firm's survival is taken to depend upon increased differentiation and more complex or sophisticated co-ordination. As You and Wilkinson note, the " result of this greater subdivision [is that] the parts of the system become increasingly mutually dependent and therefore necessarily co-operative" (You and Wilkinson 1994: 261). Increased specialisation requires the increased dependence between the elements of a productive system (labour, machines, services, etc.). When such dependence is *realised* the elements stand in a relation of technical interdependence or technical co-operation. However, such technical co-operation can be brought about, and economies of scale achieved, in various ways. Of particular importance for the following is the technical co-operation brought about by the development of close relations between (typically small) firms. Here technical co-operation is realised through social co-operation, that is, it is based upon relations of trust and reciprocity between firms rather than (typically) command and obedience relations between agents in firms. In consequence, any economies of scale which are secured are *external* to particular

(small) firms but *internal* to the productive system (industrial district) as a whole.

Marshall's comments about the location of industries involve a combination of these ideas of technical co-operation and social co-operation. In this respect, Marshall lists and combines such factors as the local market for special and hereditary skills, the use (and sharing) of highly specialised machinery, and the growth of subsidiary trades. Marshall links the importance of all these factors to a general climate or 'industrial atmosphere' (see Bellandi 1989 and Becattini 1990). Thus Marshall's famous comments about special and hereditary skills refer primarily to how geographical proximity enables socially co-operative means of bringing about learning and innovation:

> so great are the advantages which people following the same skilled trade get from near neighbourhood to one another. The mysteries of the trade become no mysteries; but are as it were in the air, and the children learn many of them unconsciously. Good work is rightly appreciated, inventions and improvements in machinery, in processes and the general organisation of the business have their merits promptly discussed: if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of new ideas (1947: 225).

Marshall left most of these ideas undeveloped, however, as his major concern was that of trying to explain the observed tendency towards organisational concentration, where the conditions for the realisation of *internal* economies of scale are of most importance. The recent interest in Marshall's ideas, though, has been prompted by the opposite observation, that is, of a movement away from organisational concentration, involving the increasing economic

importance of primarily *small*, geographically-*clustered* firms gaining the benefits of *external* economies.

Changing economic conditions

The 1980s and early 1990s was a period of significant economic change. Although the interpretation of these changes has become a source of much controversy, much of this revolving around the precise meaning and relative merits of such terms as Fordism, Post Fordism and the various notions of flexibility which distinguish (or connect) them,[2] broad features of this 'old era' and the reasons for its perceived crisis since the early 1970s do seem to be agreed upon. These features include i) tensions arising from the technical and social rigidities of mass production, especially following from the need to balance 'ever-longer and more rigid production lines' with growing problems connected to labour militancy, and poor worker morale, ii) the increasing problems for national economic management caused by increasing globalisation, iii) the increasing fragmentation of markets as an effect of the differentiation of the demand for consumption goods - this being at odds with standardisation and not easily satisfied through mass production. The emergence of economies of scope as the main source of competitive advantage is usually understood to be the most significant feature of this 'new era':

> [u]nder mass production [Fordism], subdivided labour and dedicated equipment can reduce unit costs through economies of scale, extending the market for standardised goods and facilitatory new investments in special purpose technologies, which further reduce costs, extending the market and so on. Under flexible specialisation [Post Fordism], conversely, versatile labour and universal equipment can reduce the cost of customisation through the economies of scope, extending the market for differentiated goods and facilitating new

investments in flexible technologies, which narrow the price premium for customised products, extend the market and so on (Hirst and Zeitlin, 1992).

For many commentators, the major impetus for change is understood to be the changing nature of demand. In particular, demand is viewed as 'more sophisticated' involving greater variability and segmentation into market niches[3].

Two main (related) areas of study have been identified as being of particular importance given these changes. The first is the networking activity of small firms. For a variety of reasons, typically involving some idea about increased flexibility, larger firms have sought to split up their existing operations. Moreover, new firms tend to be smaller in size and appear to show less interest in growing to a much larger size. Consequently, these smaller firms (and smaller units of once large firms) have had to develop all manner of linkages to other complementary firms and institutions as the number of tasks which can be performed within each firm becomes relatively smaller. However, the nature of the relations between these firms is not well captured by traditional notions of market relations; for example, these firms appear often to have only a very small number of potential customers or suppliers. The accompanying shift in focus on the part of academic observers and researchers has been described as a move away from markets and hierarchies within markets to *networks* (see especially Thompson et al, 1991). Here, the boundaries of the firm are understood to be quite fluid and forms of activity which were co-ordinated via 'command and obedience' relations within one organisational unit are now co-ordinated via inter-firm relations - partnerships, subcontracting relations, joint ventures or simply non-contractual, trust-based agreements.

The second area of study is that of learning activity. Reference is made to the growing importance of 'knowledge' in establishing a

firm's competitive position. Clearly, knowledge of some sort has always been important to the success of a firm. But more recently various observers have pointed to a qualitatively different role for knowledge in the firm's competitive performance. In particular it is argued that there has been a non-transitory movement away from (static) price competition (Porter, 1990) to the generation of entrepreneurial rents (Spender, 1994) through innovations in the production process, by accessing new, distinctive markets. Rather than new technology emerging sporadically after which it slowly diffuses (returning firms to conditions in which they must compete in predominantly price terms), there is a tendency towards a state of affairs in which new technological developments occur so quickly that the conditions for simple price competition do not re-emerge. Although it is thought that such developments are present across a wide spectrum of manufacturing activities, most interest has centred around the activities of high technology, research-intensive firms where the proportion of sales which result from innovations is relatively high.

Italian (NEC) industrial districts

The north-eastern-central Italy industrial district (the NEC model - see Malecki, 1991: 233), is commonly regarded to be the productive system which takes best advantage of these changing economic conditions, and to some extent exemplifies the new era. The NEC model certainly has the advantages that it has been developed from extensive empirical research and that there appears to be far greater agreement about the factors that underlie these areas' success than there is concerning apparently comparable localities such as Baden-Württemburg in Germany, Jutland in Denmark, or Silicon Valley in the US, (Pyke and Sengenberger 1991).

The NEC districts are clear examples of the Marshallian industrial district, their main features being product and labour specialisation

within an 'industrial atmosphere' (Bellandi 1989). Product specialisation is understood to exist at the industry rather than firm level (Sabel 1982); firms are then engaged in task-based rather than product-based specialisation. Labour specialisation often takes place along the whole production chain and related business services. This specialisation is not something which can easily be produced but is the outcome of a long period of time in which a large enough final market is built up to guarantee a respectable volume of demand. However, as Marshall observed, there is more at work here than increased interdependence arising from intense specialisation (or technical interdependence). It is this 'something else' that is the main focus for recent authors concerned with invoking the Marshallian notion of 'industrial atmosphere'. One important aspect of this idea is the way in which industrial districts foster or support conditions conducive to knowledge creation, inventiveness, information dissemination and utilisation, in exactly the way Marshall talks about the advantages of localised hereditary skilled labour quoted above. Thus the 'something else' is not separate from the process of increased dependence brought about by intense specialisation but is emergent from it. The basic mechanism is well captured by Brusco and Sabel:

> a customer of a small firm typically arrives with a problem to solve...The job of the small firm is to find some technically and economically feasible solution to the problem, thus creating a new product and defining the customer's need at the same time (Brusco and Sabel 1981).

Although such modifications are often of only limited interest (for example solely to the original client), the result is increased dependence and an environment facilitative of further co-operation[4]. Here a firm's capacity to solve its clients' problems depends upon the close collaboration of workers with different kinds of expertise and between variously specialised firms, such collaboration taking

place over matters of production at a viable price, compatibility, and other factors, resulting in more collaboration.

It is such processes which are most often put forward as the key to the success of these districts (McArthur 1989, Becattini 1991, Trigilia 1991). More specifically, the defining essence of the industrial district is thought to be the particular mixture of competitive and co-operative relations which exist between firms in the district (Brusco 1990, You and Wilkinson 1994, Pyke and Sengenberger 1991, Sengenberger and Loveman 1987). The actual forms that co-operation takes in industrial districts are well documented, the most common forms being the sharing of technical information, subcontracting out to (often less successful) competitors, refraining from wage competition and labour poaching (Brusco 1981, Sabel and Zeitlin 1985: 146-9, Lorenz 1992). However, whilst the importance of co-operation is thought to be central, there is in fact little elaboration of the general nature of co-operation or of the trust and reciprocity which it is meant to involve. In Piore's words: "there is no theory explaining co-operation within industrial districts, a fact which probably explains the limited success of policies designed to create industrial districts" (Piore 1990: 9-11)[5]. Although there is a growing literature on trust, and even on the possibility of constructing trust where is does not exist[6], it is fair to say that in much of the industrial district literature such generalisation is undeveloped, the focus instead being upon specific, cultural reasons for the existence of co-operative links in the NEC areas, such as extended family and community or religious ties which have traditionally proved capable mechanisms for mutual assistance, or provision of funds for establishing new businesses. But such factors do not seem to be transferable to other parts of Italy, let alone other countries (Courault and Romani, 1992)[7].

Problems for transferability also issue from the typically non-high-technology orientation of the standard NEC model. As Amin (1994,

21) notes, the clearly high innovative capability of (NEC) industrial districts:

> rarely amounts to an excellence in the developmental application of advanced technologies ...[these] districts in the main derive their competitive strengths from the use of flexible, multi-purpose, technologies (which could be traditional or electronic), craft ability and product adaptability.

Another limitation of the industrial district literature is that it neglects important world-wide trends towards the proliferation of global networks composed of 'multinational galaxies of firms' (Dunning, 1988). Such trends raise various questions. For example, do they signal a different role for local districts and changes in policies designed to foster them (Harvey, 1988) or do such trends increasingly point to the inevitable demise of industrial districts and thus the misguidedness of policies aimed at stimulating them (Nolan and O'Donnel, 1991)?

To take stock, the key feature of the literature focusing upon the NEC industrial districts is that economic success (of a region) depends upon the existence of a particular combination of competition and co-operation within the region, the latter occurring, predominantly, between successive stages in the production chain. A series of criticisms of the industrial district literature, or more correctly, criticisms of the relevance of the idea of an industrial district to other regions, have been noted. Although these do not necessarily cast doubt on the analysis of the NEC Italy region, they do cast doubt on the generality of the model used in this analysis. In response, various accounts attempt to develop or extend the ideas contained in the industrial district literature; they attempt to develop the core ideas of the industrial district to predominantly high-technology areas within global networks of relations in a variety of different localities[8]. Of particular importance here is the work of the

GREMI economists, revolving around the concept of the 'innovative milieu'.

3. Innovative milieux

The basic conception of an innovative milieu has been developed by a number of research teams from various countries working under the heading GREMI - *Groupe de Recherche Européen sur les Milieux Innovateurs* (see especially Aydalot, 1984; 1986; Aydalot and Keeble, 1988; and Camagni, 1991). Although the innovative milieu concept has been used to organise a wealth of empirical work, the term itself is rarely consistently or clearly specified (see Tödtling 1990; D'Arcy and Giussani 1994). The first task, then, is to clarify what is meant by an 'innovative milieu' and how this concept relates to that of the 'industrial district'.

The term innovative milieu was coined and developed by Aydalot (1984, 1986). Although the point of departure for the NEC industrial district literature is changing economic conditions, the background to Aydalot's work is a dissatisfaction with conceptualisations of spatial patterns at a quite general level of analysis. In particular, this dissatisfaction is with, on the one hand, the neoclassical convergence theories in which there is a tendency towards an equalisation of the rates of remuneration of production factors across areas and, on the other hand, the (core-periphery) divergence theories in which spatial advantages and disadvantages are understood simply to reinforce or reproduce themselves - thus core regions possess cumulative and durable advantages over peripheral areas. The point of entry for Aydalot and the GREMI economists is the observation that whilst the convergence theory is clearly false, neither is it the case that the relative advantage or disadvantage of some region is unchangeable (Maillat and Lecoq, 1992). Moreover, although various broad trends have been observed, especially a movement from northern industrial areas to southern rural areas (often termed the 'revenge of the south

over the north' - Berger et al. 1988), there has been little success in finding a simple relationship between economic revitalisation and geographical location.

Aydalot and his followers, in response, emphasise the inadequacy both of only considering the (typically large) single company and/or of ignoring endogenous features of innovation. Thus as a corrective, the local or regional *environment* is seen as the relevant unit of analysis. Moreover it is the particular ability of an environment to foster *innovation* which is the central concern. The ability to innovate is considered to underlie changing spatial patterns and it is the "milieux which act as entrepreneurs and which innovate" (Aydalot, 1986). In this case, the relevant questions are "[w]hy some environments innovate more than others [and] why innovative environments sometimes cease to innovate?" (Aydalot and Keeble, 1988: 9). To argue that it is the 'milieux' which are the 'innovators' is not to attribute some notion of agency to a region but to emphasise that innovation results from a process of interaction. In Camagni's words [a]n innovative 'milieu' may be defined as the set, or the complex network, of mainly informal social relationships on a limited geographical area, often determining a specific 'image' and a specific internal 'representation' and sense of belonging which enhances the local innovative capability through synergetic and collective learning processes (Camagni 1991: 3).

In other words, the intention is to emphasise the importance of linkages between firms - linkages which are not simply concerned with material transfers.

Predominantly, the concept of the milieu has been restricted to descriptions of high-technology areas (see especially Aydalot and Keeble, 1988). However, there are various problems involved in attempting to distinguishing milieux by their 'high-tech-ness'. For instance, in defining high technology, as Malecki notes, "everyone

knows what it is, but no two definitions are alike" (1991: 174). Does a notion of high technology necessarily involve innovativeness? Certainly high technology firms are considered to be innovative firms, as Thompson puts it "if there is an 'essence' to high technology, it is surely the 'newness' and 'difference' brought to products and processes through the application of scientific research" (1989: 136). But high technology and innovativeness are not the same things. It is illustrative here to consider some of the main attempts to define high technology. One commonly made distinction is between *product* and *process* notions of high technology. The argument for making this distinction is that there is a need to distinguish *producers* of high-technology products as being more innovative than the down stream users who incorporate the products as process innovations (McQuaid, 1984). Certainly, a failure to distinguish product and process easily leads to a definition of high technology that covers most of manufacturing, since it is hard to conceive of relatively competitive firms which are not high technology in terms of processes (Northcott and Rodgers, 1982). However, various problems exist with these distinctions. Apart from the various problems in categorising product innovations or process innovations (Combs and Kleinknecht 1983), such a distinction serves to down play the importance of innovation arising from producer-user collaboration which is clearly central to the success of industrial districts, as noted above. The *surrogate criterion* approach is that in which certain characteristics of high-technology industries are identified. The criteria most commonly focused upon are: 1) R&D expenditures as a percentage of net sales, and 2) numbers of technical workers (scientists, engineers and technicians) as a percentage of the workforce - or the R&D/SET-based definitions (Thompson, 1988). Often some attempt is made to combine the two, as for example in the UK government's definition of high-technology industries (Butchart, 1987). Various problems exist with such surrogate measures. For example, the motor car industry in which huge amounts of R&D and large numbers of technical workers

generate highly sophisticated products is not usually defined as high technology because this still makes up a relatively small proportion of annual sales or total workforce. More generally, various studies cast doubt on the relationship between R&D expenditure and innovative ability. For Pavitt, R&D is at best an intermediate output in the process of innovation and likely to be a poor proxy at that; R&D expenditures are instead best viewed as a 'measure of the professionalisation and specialisation of innovation-based activity' rather than innovativeness per se (Pavitt, 1984, Pavitt et al 1987)[9]. Malecki notes that Japanese thinking is somewhat different to the surrogate criterion approach, focusing upon the 'system oriented' nature of high technology (Malecki, 1991: 176). Here the emphasis is upon core technologies associated with potential 'long-wave upswings' (see for example Imai 1988:206). This line of reasoning is also behind McArthur's diffusion-based approach (McArthur, 1990). Here a distinction is made between *newly emerging* and *widely diffusing* technologies, both of which are considered to be high technology.

Perhaps the most obvious lesson to be learned from such a brief review of definitions is that different definitions of high technology will be more or less relevant depending upon the question under consideration. For the present purposes, where the relation between proximity and innovation is central, one particular distinction turns out to be central. On the one hand we can distinguish between producer-user-type innovation where the basic mechanism, as noted above, is through collaboration along the same production chain. Such innovation may primarily involve process innovations; the application for the innovation is clearly identified and the access to resources for its implementation are at hand. Alternatively, what I shall term incubator-type innovation, is not restricted to producer-user interaction. The application for this type of innovation is likely to be wide and uncertain, and the 'lead time' between development of the innovation and implementation is likely to be long. Moreover,

access to the resources necessary to implement the innovation is not typically guaranteed. Both types of innovation are likely to be high tech, and newly emerging in McArthur's sense, but will typically come about through different processes with differing roles for proximity.

Now, the GREMI contributions are clearly concerned with high-technology regions. Although high technology is not precisely defined, and although producer-user-type and incubator-type innovation are both considered, it is fair to say that the main focus of attention is upon incubator-type innovation and the importance of geographical proximity to this particular type of innovation. The point to emphasise is that the dominance of user-producer relations in industrial districts has restricted the kinds of investigations pursued. Frequent interaction/collaboration along production chains, or problem-solving revolving around sequential stages in such chains, have obviated the need to ask such questions as how are links formed, or how is uncertainty about lead times, applications of innovations and access to resources, dealt with? In short, in the industrial district literature a generalised notion of innovation itself is left undeveloped. In the innovative milieux literature, in contrast, this task is central. That this is so is brought out if we consider the particular features of the milieu most commonly emphasised and, in particular, how the milieu is presented as generating or facilitating innovative behaviour. On the one hand, the milieu is understood to affect innovating capabilities directly, enhancing learning and creativity. For example, Bramanti and Senn (1991) distinguish various types of innovation and 'stages' (or perhaps better, components) in the innovation process: information - which is quickly and easily exchanged and often has its sources from far afield, that is, not primarily milieu dependent; knowledge - which incorporates the 'ability' to absorb or internalise information, which is highly influenced by the milieu; competence - know-how connected to the individual or collective's learning processes which

are almost completely milieu dependent; creativity - which is viewed as some kind of 'synergetic meeting of information, knowledge and competence' and thus is a mixture of intra and extra-milieu features (Bramanti and Senn, 1991).

Other accounts focus upon types of uncertainty which are especially relevant to high-technology innovation and the various means of acting capably in the presence of such uncertainty (see especially Camagni, 1991). First, there is the uncertainty which follows from the complexity (and cost) of the information which needs to be collected. In order to overcome such uncertainty the relevant activity is a *search* function to discover information. Secondly, uncertainty arises from the problem of inspecting *ex-ante* the qualitative features of inputs or equipment needed for production. Here the relevant function is that of *screening* (market) signals and assessing the hidden qualities of such inputs and equipment. Thirdly, there is a problem concerned with the ability of the firm to process and understand the available information. This problem can be understood to lead to a function of *transcoding*. This involves utilising codified information, both freely available or costly, and merging it with tacit and informal 'information' flow into firm-specific 'knowledge' and possibly into potential business ideas at the disposal of managerial decision-making (Camagni, 1991: 127). Fourthly, there are the problems of assessing the outcomes of one's own actions. The problem highlighted here is that of selecting or coming to adopt particular decision routines (in the manner investigated by Nelson and Winter, 1982). Lastly, there is the problem of assessing the actions of others and their interaction.

Although various accounts exist of the strategies that firms develop to cope with such uncertainty (for example, Williamson's notion of hierarchy is often invoked to cope with this latter problem of assessing the actions of others), the importance of the GREMI approach, in Camagni's view, is to consider the local 'milieu' as

perhaps the most important 'uncertainty-reducing operator'. *Collective information gathering and screening* takes place through informal interchange of information between firms signalling various successful decisions or reputation. A *collective learning process*, for the most part through skilled labour mobility within the local labour market, customer-supplier technical and organisational interchange, imitation, application to local needs or general purpose technologies and informal cafeteria effects, enables the transcoding function. A *collective process of selecting decision routines* results from managerial mobility, imitation, and co-operative decision-making through local associations. Finally it is argued that an *informal process of decision co-ordination* is achieved via interpersonal linkages through families, clubs, associations and other social organisations, which has the advantage of easier and faster information circulation and similar cultural backgrounds. The milieu also performs other tasks, such as converting potential production factors (especially labour) to match the qualitative needs of local firms (the *transformer* function). Accordingly, Camagni (1991, 132) then defines the 'milieu' as the:

> collective operator reducing the degree of static and dynamic uncertainty for the firms by tacitly or explicitly organising the functional and informational interdependence of local actors and informally performing the SSSTTC functions (search, signalling, selection, transcoding, transformer and control).

Such features are used to explain why innovation creation and diffusion is highly enhanced in certain areas. Additionally such features are used to explain the relative success of small firms in these areas. The argument is that these various different types of uncertainty raise the minimum efficient firm size. The countervailing tendency is that sufficient 'milieu' effects reduce uncertainty and so allow small firms to survive.

This emphasis upon small firms and the incubator role of the milieu raises the question of whether the milieu is ultimately a short-run phenomenon, of little relevance after the information intensive phases of the product cycle (D'Arcy and Giussani, 1994). In response, more recent GREMI contributions have focused upon the ability to develop linkages outside the milieu itself, such linkages being termed *Innovation Networks*. Such networks are defined as "a closed set of selected and explicit linkages with preferential partners...having as a major goal the reduction of...uncertainty" (Camagni, 1991: 135). Several comments are relevant here. The first point is that these wider networks are defined as formal, explicit and consciously chosen. Typically, the term network is reserved for informal, tacitly known and acted upon relations (for example, see Thompson et al, 1991). However, in the GREMI literature such informal relations are seen as overwhelmingly localised and internal to the milieu. In contrast to these informal milieu relations, innovation networks are consciously chosen, formal links. To repeat, these links are understood as strategies to overcome the longer term problems of milieux, problems which may prevent success beyond the incubator phase. Various problems are considered in the literature which are either external or internal to the milieu. An obvious example is that of external changes in economic conditions leading to generalised decline (especially in the case of very specialised and homogeneous local manufacturing systems). Additionally, two major problems have been identified which are of internal origin. The first, which can be seen as a countervailing force to the usually cited advantages of the milieu, is a need for an injection of new ideas from outside which arises because of an increased (cultural or industrial) homogenisation within the milieu (often termed the problem of entropic death). The second problem arises because of the small firm size within the milieu and refers to the need to access resources to develop new ideas and products. The main point to note here is that innovation networks, as understood above, act to solve these problems in ways which maintain the

innovative capabilities of the milieu (especially see Solé and Valls, 1991 and Camagni, 1991). Such problems may be overcome by larger firms moving into the area bringing such resources and new ideas. But such (predatory) movements may upset the very elements of the milieu upon which its success, as an incubator, relies.

In emphasising the importance of trans-regional relations, the question arises as to whether considerations of space (and the local milieu) accordingly become less important. The GREMI response is to argue that not only is it necessary to refer to links outside the milieu to explain the nature of the milieu itself but also the nature of such external networks cannot be understood independently of those within the milieu. For example, when choosing a partner to link up with, not only does the firm chose a single partner, but a link to a 'local' culture, acquiring access to the synergies of its 'milieu'. A further point, which remains largely unexplored by the GREMI research, is the extent to which the ability to develop co-operative linkages is itself a skill or resource which *once learned or acquired in the local milieu enables the construction of more useful/profitable links outside the milieu.* There does seem to be evidence to suggest that if a firm can establish successful local links it is also more likely be able to secure successful links internationally (Keeble et al, 1997). In this case, the milieu seems to act as an incubator in a double sense, not only of ideas but of the ability to develop beneficial network relationships which facilitate the development of necessary or beneficial links outside the milieu in such a way as not to destroy its own internal workings.

In sum, a sustainable conceptualisation of an 'innovative milieu' must at least account for the following a) that the economic success of many localities and regions cannot be explained in terms of traditional cost minimisation or externality approaches, b) the relevant unit of analysis is a geographically defined productive system, c) that the resulting milieu functions as an incubator of

innovation, d) that the manner in which a milieu fosters innovation provides a largely endogenous source of economic success, e) that the major characteristic of the milieu is the ease of information flows which not only stimulates incubator-type innovation directly, but reduces the uncertainty facing innovative activity, f) that the milieu acts to reduce the 'efficient' size of the firm, thus encouraging small firm growth and so the flexibility that small firm size facilitates, g) that the ability to develop network linkages within a region makes it possible to establish beneficial (more formal) networks outside the region in a manner which enables the milieu to overcome various problems without harming the internal workings of the milieu itself.

4. Milieux, districts and the importance of proximity

The milieu and the district concepts are clearly overlapping. Both refer to geographically defined productive systems where the success of the system depends crucially upon the nature of the linkages which emerge and are reproduced by the elements. Furthermore, there are clear developments in both as regards the manner in which geographical proximity enables or facilitates the kinds of links thought to be of particular importance. In both the above literatures, concern with links has involved a movement away from simple input-output relations to a consideration of the rules, conventions, and social relations which allow more effective learning, knowledge acquisition and development, or, more generally, allow agents to act in capable - innovative - ways[10].

Trust and tacit knowledge

Two factors are especially important here. The first of these relates primarily to the means by which such knowledge is acquired and the second relates to the nature of such knowledge. More specifically, the former relates to those types of relations which are most conducive to innovating activity (and which are themselves

facilitated by geographical proximity). An important example of this kind of relation is that of trust. For example, trust is likely to be facilitated by continuous interaction (through cafeteria effects, as well as through actual transactions). Furthermore, trust will be more easily established where knowledge of the trustees is easily gained. This is likely to be facilitated by the relatively high levels of intra-region labour mobility and spin-off activity characteristic of high-technology sectors. Furthermore, trust may be easier to establish locally simply because agents may not wish to be seen to act unfairly with other local firms - feeling that once a reputation is lost locally it might not be redeemable. Also implicit in the two literatures outlined above is the idea that geographical proximity is important to the innovation process because of the nature of the knowledge in question. In particular an increasing focus is placed on the importance of uncodified information. The main sources here are the ideas of tacit knowledge set out by Polanyi (1962, 1966) and those of the embeddedness of knowledge in Granovetter (1985). Various accounts have pointed out that just as the establishment of information 'super-highways' or the high mobility of skilled workers, erodes the potential areas in which a firm can distinguish itself on the market, the non-codified results of knowledge creation - embedded tacit knowledge - become relatively more important in establishing a firm's competitive position. It is, moreover, the "fundamental 'exchange inability' of this type of knowledge that increases in importance as internationalisation proceeds" (Malmberg & Maskell, 1995). The main point is that such knowledge is difficult to codify, standardise or transfer and may, ultimately, only be transmittable indirectly, via the kind of repeated interaction or collaboration that geographical proximity allows[11].

Collective learning

To return to the differences between districts and milieux, the former are, primarily, sectorally specialised areas in which the major

benefits of proximity follow from regularly repeated interaction (recontracting) between productive agents located at sequential stages along the production chain. However, the milieu is not sectorally specialised[12] and gains such as trust, reciprocity, flexibility and responsiveness cannot be seen to follow from industrial district type vertical linkages. The main form of innovation in the high-technology milieu is not likely to be of the producer-user type. Here the particular types of uncertainty associated with the development of new products and processes, such as long 'lead times', or unavailability of resources to develop products, would appear to encourage a wide range of, often primarily horizontal, linkages concerned with facilitating flows of information. The implication for conceptualisations of milieux is that mechanisms by which proximity facilitates such advantages need to be more explicitly considered. It is such considerations which appear to motivate the emergence of, and more recent attempts to refine, the idea of 'collective learning'. In other words, the concept of collective learning is an attempt to trace out the mechanisms by which proximity influences innovative behaviour - where a more general notion of innovation (than simple user-producer) is considered.

Much effort within the early GREMI literature is made to define different types of 'innovative milieu'. On one level the term collective learning is a second-order term, being defined simply as the learning made possible by membership of some particular type of milieu, the main emphasis being on the nature of the milieu in question. More recently there have been various attempts to develop the notion of collective learning more directly. For example, Camagni (1991) focuses upon the uncertainty arising from what was termed above the 'competence gap'. Learning, on this account, is not simply the acquisition of information. In fact the availability of information is not a central issue here - instead it is (or at least must include) the process by which (available) information becomes (useable) knowledge. Such a 'transcoding' function is achieved by

'links-based' and 'non-links-based' factors. Singled out to be of importance on the linking side are supply chain linkages or links established via the movement of labour between firms (either acting to transfer information 'once and for all' by taking expertise/ knowledge or acting to establish an ongoing link between the firms via the personal relations maintained between the moving employees and previous colleagues). But spin-off activity is likely to be another vital source of such linking, especially in high technology areas where the rate of new start ups and hence spin offs is high. Non-linking forms of such learning include imitation, emulation, or reverse engineering. Membership of a milieu, or just proximity to other firms, are clearly still important here, but not because of sustained or repeated interaction.

The point to stress in Camagni's discussion is that whilst knowledge is central to the competitive success of the firm, and whilst the existence of linkages and emulation is important for such success, linkages or emulation do not simply transfer knowledge directly but *facilitate* knowledge transfer. Another way of expressing this is that they help to match "signals and beliefs". The local milieu "... performs just this function, attributing reliability to signals and spreading the acceptance of a common vision about the state-of-the-world" (p.132). Camagni talks about various aspects of the milieu to illustrate these ideas. The milieu helps to create a local 'external image', an internal 'industrial atmosphere', common 'cultural roots', and 'tacit codes'. However, the mechanisms whereby such knowledge is generated are left undeveloped.

A more sustained attempt to define the notion of collective learning is provided by Lorenz[13]. Lorenz' starting point is the literature on learning processes within the firm (for example, March, 1991). The primary focus in this literature is with cognitive processes and, specifically, with the role of firms and organisations in reconciling actual or potential conflicts which emerge from the differences

existing between the beliefs, understandings, and representations held by individuals. Firms and organisations thus, through the construction of *shared knowledge*, serve to overcome a form of co-ordination problem by establishing commonly understood rules and accepted procedures. Collective learning can be understood as an extension of this idea in which the emergence and development of basic common knowledge and procedures across a set of firms facilitates co-operation and solutions to common problems.

More specifically, Lorenz sets out three areas in which firms need to develop shared knowledge. First, there are the preconditions for learning. There is the need to establish a common language for talking about organisational and technical problems. Furthermore, there is the need to establish common standards of honesty and information sharing as the basis for the adaptation of industrial partners to unanticipated contingencies not explicitly provided for in formal contracts. As Lorenz points out, "a clear understanding of and mutual consensus over the rules provides a basis for the progressive build-up of the trust, which is arguably indispensable for innovative collaboration, given the uncertainties which surround its terms and outcome." Secondly, there is a need for shared knowledge of a more strictly technological or engineering nature which allows firms to collaborate in a technological project. This knowledge is not simply (or most importantly) concerned with core research but with the more 'down stream' phase of innovation, involving detailed product design, testing, redesign and production. This 'in-house' knowledge is often difficult to transfer because it is not easily codified and its transfer ultimately depends on the mobility of individuals or teams with practical experience. The third kind of shared knowledge is of a more organisational type. Lorenz uses as examples hierarchical relations, the division of responsibilities among different occupations and services, and the procedures which assure the consistency of collective decision making. More generally, these rules and procedures directly define the positions (rights, obligations) of

individuals within organisational units and relate to the relative importance of command and obedience relations, or of flat management structures, as well as the kind of knowledge needed to co-ordinate reliable extra-firm relations, for example with sub-contractors. Thus the whole idea of collective learning is to identify and understand the processes by which locally based factors act to facilitate learning amongst the whole ensemble of local firms and organisations, whether this involves transforming available information into useable knowledge or whether it involves the establishment of common or shared knowledge of various forms. It is in this regard that such factors as the nature of labour mobility or of spin-off activity within the locality are likely to be of key importance.

5. Concluding Remarks

This paper has reviewed a series of contributions which have sought to develop the ideas of the 'industrial district' and the 'innovative milieu' in order to explain the continuing importance of regional clusters of high technology firms. The review reveals various trends. First, it is the productive system as a whole which is taken to be the most appropriate unit of analysis, rather than particular firms or institutions. Secondly, there has been a movement in focus away from input-output-type relations to a consideration of the less tangible absorptions and exchanges between agents and the qualitative nature of the rules, conventions and social relations which allow agents to act in capable - innovative - ways. Thirdly, although the classic NEC literature contains various advantages as regards the articulation of basic ideas, it also contains various disadvantages which are typically referred to in terms of the transferability problems of the basic model. The innovative milieu literature has been presented here as a response to these problems of generality - problems which are typically understood to involve neglect of the high-technology and globalised nature of the firms involved. I have

argued that these differences are best understood by distinguishing types of innovation, namely producer-user and incubator innovation, and understanding the NEC model to be primarily a subset of the former. Direct consideration of the latter type of innovation opens up the need to study the various means by which learning is achieved - the various types of relationship which facilitate innovation. The need then is to conceptualise factors which are generic to the deeply context-dependent processes of learning detailed in these accounts. I have argued that it is for this purpose that the term collective learning is most appropriate.

Various implications follow for the researcher or policy maker. First, it is likely to be very difficult to gain knowledge of the kinds of linkage identified in the new literatures. The main attraction of more traditional input-output-type linkages is that they are relatively easy to measure. The changes in focus referred to here present new challenges for the empirical researcher, in particular, in disentangling the specific cultural conditions which surround these linkages from more generic features. Secondly, those factors that have been isolated such as the importance of trust, co-operation and learning are not easily encouraged by the policy maker. No clear or easy policy options exist to stimulate these factors and, more often, even under conducive circumstances, they may simply require time. Recent research is, however, surely on very strong ground in insisting that co-operation, trust, collective learning and the reduction of uncertainty are factors which are all of immense importance to innovation and general economic success, especially by small and medium sized firms, and are all factors which are encouraged by geographical proximity.

Notes

1. The term *productive system* (Wilkinson 1983) is used in preference to the more widely used *production system* in order to avoid the bias towards input-output linkages implicit in the latter.

2. The term Fordism has a rich history (being popularised by Ford himself and embraced by Gramsci in the Prison Notebooks - see Clarke 1992). More recently the distinction has appeared in three main guises - the flexible specialisation interpretation (most notably of Piore and Sable, 1984, but see also Sabel (1982), Sabel and Zeitlin (1985), Hirst (1989) and Hirst and Zeitlin (1992)), the long wave interpretation (especially of Freeman and Perez, 1988 and Perez, 1983), and the work of the French Régulation school (see Aglietta, 1979; Boyer, 1979; 1988; and Lipietz, 1987; 1994 - for a comparison see especially Jessop, 1990; 1992).

3. In the flexible specialisation literature this change in demand provokes a ratchet-like notion of progress (in which there is 'no going back'). In contrast, the long wave interpretation of Post Fordism, which draws heavily upon the work of Kondratiev and Schumpeter (see Freeman and Perez, 1988; and Perez, 1983), contains a more complex notion of progress. Various types of innovation are distinguished, the major point being that certain types of technological change (i.e. in the 'technoeconomic paradigm') have such widespread consequences for all sectors of the economy that their occurrence leads to major structural crises of adjustment and a pressure for social and institutional changes. Here, (high-technology) innovation is a (recurring) feature of periods of transition. Thus such features as the co-operative or non-price based activities of innovating firms, which flexible

specialisation accounts associate with a new era, may simply be a feature of a necessary but transitory stage to a new era.

4. Some modifications of course will prove to be more widely applicable. Such circumstances appear to be especially important for start up of new businesses (Capecchi 1989).

5. On the problems of transferring these ideas see also Amin and Robbins; 1990, Sforzi 1990.

6. For example see Lane, 1997; Lazaric and Lorenz, 1997.

7. In fact it is not even clear that these features are sustainable within NEC areas (Brutti and Calistri, 1992).

8. For example the concepts of a technology district (Storper 1992, 1993 and see also Dalum, 1993), technological district (Dupuy and Gilly, 1992), or territorial complex (Stöhr, 1986).

9. Indeed, high technology is a term not used in these accounts, which prefer the term science based.

10. Although there is not space to develop the argument here, this movement (in focus) from material-based linkages to the underlying structural conditions facilitative of innovative activity is discernible in various prominent accounts. One obvious example is the movement from traded to untraded interdependencies in the work of the Californians such as Storper and Scott (see Lawson et al, 1996), another is the recent focus upon competence theories of the firm (Lawson, 1997).

11. For a general review of the relevance of tacit knowledge in this regard, see Howells, 1995.

12. Other than in such broad terms as high technology.

13. Here I am drawing upon a presentation given to the European Network on 'Networks, Collective Learning and RTD in Regionally-Clustered High-Technology SMEs', personal communications and a forthcoming paper written with Lazarac (1997).

References:

Aglietta, M. (1979), *A Theory of Capitalist Regulation*, New Left Books, London.

Amin, A. (1994), The difficult transition from informal economy to Marshallian industrial district, *Area*, vol. 26, no. 1, pp. 13-24.

Amin, A. and Thrift, N. (eds) (1994), *Globalisation, Institutions and Regional Development in Europe*, Oxford University Press, Oxford.

Amin, A. and Thrift, N. (1992), Neo-Marshallian nodes in global networks, *International Journal of Urban and Regional Research*, vol. 16, no. 4, pp. 571-587.

Amin, A. and Robins, K. (1990), Industrial districts and regional development: limits and possibilities, in Pyke et al, *Industrial Districts and Inter-Firm Co-operation in Italy*, International Institute for Labour Studies, Geneva.

Aydalot, P. (1984), The reversal of spatial trends in French industry since 1974, in Lambooy, J.G. (ed.), *New Spatial Dynamics and Economic Crisis*, Finnpublishers, Tampere.

Aydalot, P. (ed) (1986), *Milieux Innovators en Europe*, GREMI, Paris.

Aydalot, P. and Keeble, D. (eds) (1988), *High Technology Industry and Innovative Environments: the European Experience*, Routledge, London.

Becattini, G. (1990), The Marshallian industrial district as a socio-economic notion in Pyke et al, in *Industrial Districts and Inter-Firm Co-operation in Italy*, International Institute for Labour Studies, Geneva.

Bellandi, M. (1989), The industrial district in Marshall, in *Small Firms and Industrial Districts in Italy*, Goodman et al. (eds), Routledge, London.

Berger, A., Catanzano, J., Fornairon, J. D. and Rouzier, J. (1988), *La Revanche du Sud*, L'Harmattan, Paris.

Boyer, R. (ed) (1988), *The Search for Labour Market Flexibility*, Clarendon Press, Oxford.

Boyer, R. (1990), *The Regulation School: A Critical Introduction*, Columbia University Press, New York.

Bramanti, A. and Senn, L. (1991), Innovation, firms and milieu: a dynamic and cyclic approach, in Camagni, R. (ed.), *Innovation Networks: Spatial Perspectives*, Belhaven Press, London.

Braudel, F. (1979), *Les Jeux de l'Echange*, Armand Colin, Paris.

Brusco, S. (1986), Small firms and industrial districts: The experience of Italy, *Economia Internazionale*, vol. 39, no. 2, pp. 98-103.

Brusco, S. (1990), The idea of an industrial district: its genesis, in Pyke et al, *Industrial Districts and Inter-Firm Co-operation in Italy*, International Institute for Labour Studies, Geneva.

Brusco, S. and Sabel, C. (1881), Artisan production and economic growth, in *Dynamics of Labour Market Segmentation*, Wilkinson, F. (ed), Academic Press, London.

Brusco, S. and Righi, E. (1989), Local government, industrial policy and social consensus: the case of Modena (Italy), *Economy and Society*, vol. 18, no. 4, pp. 405-424.

Brutti, P. and Calistri, F. (1990), Industrial districts and the unions, in Pyke, F., Becattini, G. and Sengenberger, W. (ed.), *Industrial Districts and Inter-Firm Co-operation in Italy*, International Institute for Labour Studies, Geneva.

Butchart, R. (1987), A new definition of high technology industries, *Economic Trends*, no. 400, pp. 82-88.

Camagni, R. (ed) (1991), *Innovation Networks: Spatial Perspectives*, Belhaven Press, London.

Camagni, R. (1991), Local 'milieu', uncertainty and innovation networks: towards a new dynamic theory of economic space, in Camagni, R. (ed.), *Innovation Networks: Spatial Perspectives*, Belhaven Press, London.

Camagni, R. and Quevit, M. (eds) (1992), *Innovation Policies at the Local Level*, Dipartimento di Scienze Economiche, Padova.

Capecchi, V. (1990), A history of flexible specialisation and industrial districts in Emilia-Romagna, in Pyke et al, *Industrial Districts and Inter-Firm Co-operation in Italy*, International Institute for Labour Studies, Geneva.

Clarke, S. (1992), What in the F---'s Name is Fordism, in Gilbert, N., Burrows, R. and Pollert, A. (ed.), *Fordism and Flexibility: Divisions and Change*, Macmillan, London.

Coombs, R. and Kleinknecht, A. (1983), New evidence on the shift toward process innovation during the long wave upswing, pp. 7-24 in Freeman, C. (ed.), *Design, Innovation and Long Cycles in Economic Development*, Design Research Publications, London.

Crevoisier, O. and Maillat, D. (1991), Milieu, industrial organisation and territorial production system: towards a new theory of spatial development, in Camagni, R. (ed.), *Innovation Networks: Spatial Perspectives*, Belhaven Press, London.

D'Arcy, E. and Giussani, B. (1994), Local economic development: changing the parameters?, in *Discussion Papers in Urban and Regional Economics*, University of Reading, Series C, no. 96.

Dalum, B. (1993), North Jutland - a 'Technology District' in Radiocommunications Technology?, *FAST*, vol. 25-26, pp. 165-215.

Dupuy, C. and Gilly, J.P. (1992), 'Industry and territory: localised productive systems', unpublished working paper, Toulouse.

Freeman, C. and Perez, C. (1988), Structural crises of adjustment: business cycles and investment behaviour, in *Technological Change and Economic Theory*, Dosi, G. et al. (eds), Pinter, London.

Gambetta, D. (1988), *Trust: Making and Breaking Co-operative Relations*, Basil Blackwell, London.

Goodman, E., Bamford, J. and Saynor, P. (eds) (1989), *Small Firms and Industrial Districts in Italy*, Routledge, London.

Gordon, R. and Kimball, L.M. (1992), Beyond industrial maturity: planning the future of Silicon Valley, in Camagni, R. and Quevit, M. (ed.), *Innovation Policies at the Local Level*, Dipartimento di Scienze Economiche, Padova.

Granovetter, M. (1985), Economic action and social structure: the problem of embeddedness, *American Journal of Sociology*, vol. 91, no. 3, pp. 481-510.

Hansen, N. (1992), Competition, trust, and reciprocity in the development of innovative regional milieux, *Papers in Regional Science*, vol. 71, no. 2, pp. 95-105.

Harrison, B. (1992), Industrial districts: old wine in new bottles?, *Regional Studies*, vol. 26, no. 5, pp. 469-83.

Hirst, P. (1989), *After Thatcher*, London, Collins.

Hirst, P. and Zeitlin, J. (1992), Flexible specialisation versus post-fordism: theory, evidence, and policy implications, in *Pathways to Industrialisation and Regional Development*, Storper, M and Scott, A.J. (eds), Routledge, London.

Howells, J. (1995), Tacit knowledge and technology transfer, *ESRC Centre for Business Research, University of Cambridge, Working Paper*, 16.

Imai, K (1988), Industrial policy and technological innovation, in Komiya, R., Okuno, M. and Suzumura, K. (ed.), *Industrial Policy of Japan*, Academic Press, Tokyo.

Jessop, B. (1990), Regulation theories in retrospect, *Economy and Society*, vol. 23, no. 11, pp. 7-62.

Jessop, B. (1992), Fordism and Post-Fordism: a critical reformulation, in Storper, M. and Scott, A.J. (ed.), *Pathways to Industrialisation and Regional Development*, Routledge, London.

Johnston, R. and Lawrence, P.R. (1991), Beyond vertical integration - the rise of the value-adding partnership, in Thompson, G., Frances, J., Levacic, R. and Mitchell, J. (ed.), *Markets, Hierarchies & Networks: the Coordination of Social Life*, The Open University, London.

Keeble, D., Lawson, C., Lawton Smith, H., Moore, B. and Wilkinson, F. (1997), Internationalisation Processes, Networking and Local Embeddedness in Technology-Intensive Small Firms, *ESRC Centre for Business Research, University of Cambridge, Working Paper*, 53

Lawson, C. (1997), Towards a competence theory of the region, *unpublished mimeo.*

Lawson, C., Moore, B., Keeble, D., Lawton Smith, H. and Wilkinson, F. (1996), Inter-firm links between regionally clustered high-technology SMEs: a comparison of Oxford and Cambridge innovation networks, *paper given at the High-Technology Small Firms Conference*, Twente.

Lazaric, N. and Lorenz, E. (1997), Trust and organisational learning during inter-firm cooperation, in Lazaric, N. and Lorenz, E. (ed.), *The Economics of Trust and Learning*, Edward Elgar, London.

Lipietz, A. (1986), *Mirages and Miracles*, Verso, London.

Lipietz, A. (1989), *Choisir l'Audace*, la Decouverte, Paris.

Longhi, C. and Quéré, M. (1993), Innovative networks and the technopolis phenomenon: the case of Sophia-Antipolis, *Environment and Planning, C: Government and Policy*, pp. 317-330.

Longhi, C. and Quéré, M. (1993), Local systems of innovation and territorial dynamics, *Revue Economique*, vol. 44, no. 4, July, pp. 713-24.

Lorenz, E.H. (1992), Trust, community and co-operation: toward a theory of industrial districts, in Storper, M. and Scott, A.J. (ed.), *Pathways to Industrialisation and Regional Development*, Routledge, London.

Maillat, D. and Lecoq, B. (1992), New technologies and transformation of regional structures in Europe: The role of the milieu, *Entrepreneurship and Regional Development*, vol. 4, pp. 1-20.

Malecki, E.J. (1991), *Technology and Economic Development*, Longman, Harlow.

Malmberg, A and Maskell, P (1995), Localised learning and industrial competitiveness: towards a knowledge based economy, *Conference Paper presented at the Regional Studies Association Conference on Regional Futures,* Gothenberg.

March, J.G. (1991), Exploration and exploitation in organisational learning, *Organization Science*, vol. 2, no. 1, February, pp. 35-48.

Marshall, A. (1920), *Industry and Trade*, Macmillan, London.

Marshall, A. (1947), *Principles of Economics*, Macmillan, London.

McArthur, R. (1989), Locality and small firms: some reflections from the Franco-British project, 'Industrial systems, technical change and locality', *Environment and Planning D: Society and Space*, vol. 7, pp. 197-210.

McArthur, R. (1990), Replacing the concept of high technology: towards a diffusion-based approach, *Environment and Planning A*, vol. 22, pp. 811-28.

McQuaid, R. (1984), Definition of high-technology industries, *Working Paper 2.2*, University of Reading, Reading.

Nelson, R.R. and Winter, S.G. (1982), *An Evolutionary Theory of Economic Change*, Harvard University Press, Cambridge.

Nolan, P. and O'Donnell, K. (1991), Restructuring and the politics of industrial renewal: the limits of flexible specialisation, in Pollert, A.(ed), *Farewell to Flexibility*, Blackwell, Oxford.

Northcott, J. and Rogers, P. (1982), *Microelectronics in Industry: What's Happening in Britain?*, Policy Studies Institute, London.

Pavitt, K. (1984), Sectoral patterns of technical change: towards a taxonomy and a theory, *Research Policy*, vol. 13, pp. 343-374.

Pavitt, K., Robson, M. and Townsend, J. (1987), The size distribution of innovating firms in the UK, 1945-1983, *Journal of Industrial Economics*, vol. 35, pp. 129-147.

Perez, C. (1983), Structural change and the assimilation of new technologies in the economic and social system, *Futures*, vol. 15, pp. 357-75.

Piore, M.J. (1990), Work, labour and action: work experience in a system of flexible production, in Pyke et al, *Industrial Districts and Inter-Firm Co-operation in Italy*, International Institute for Labour Studies, Geneva.

Piore, M. and Sabel, C. (1984), *The Second Industrial Divide: Possibilities for Prosperity*, Basic Books, New York.

Polanyi, M. (1962), *Personal Knowledge: Towards a Post Critical Philosophy*, Chicago.

Polanyi, M. (1966), *The Tacit Dimension*, New York.

Pollert, A. (1991), *Farewell to Flexibility*, Blackwell, Oxford.

Porter, M.E. (1990), *The Competitive Advantage of Nations*, Free Press, New York.

Pyke, F. (1992), *Industrial Development Through Small-Firm Co-operation: Theory and Practice*, International Labour Office, Geneva.

Pyke, F. and Sengenberger, W. (eds) (1992), *Industrial Districts and Local Economic Regeneration*, International Institute for Labour Studies, Geneva.

Pyke, F., Becattini, G. and Segenberger, W. (1990), Industrial districts and inter-firm co-operation in Italy: introduction, in Pyke, F et al. (ed.), *Industrial Districts and Inter-Firm Co-operation in Italy*, International Institute for Labour Studies, Geneva.

Pyke, F., Becattini, G. and Segenberger, W. (eds) (1990), *Industrial Districts and Inter-Firm Co-operation in Italy*, International Institute for Labour Studies, Geneva.

Sabel, C. (1982), *Work and Politics: The Division of Labour in Industry*, Cambridge.

Sabel, C. and Zeitlin, J. (1985), Historical alternatives to mass production: politics, markets and technology in nineteenth-century industrialisation, *Past and Present*, vol. 108, pp. 133-76.

Saxenian, A. (1983), The Genesis of Silicon Valley, *Built Environment*, vol. 9, no. 1, pp. 7-17.

Scott, A.J. (1986) High technology industry and territorial development: the rise of the Orange County complex, *Urban Geography*, vol. 7, pp. 3-45.

Scott, A.J. (1992), The role of large producers in industrial districts: a case study of high technology systems houses in Southern California, *Regional Studies*, vol. 26, no. 3, pp. 265-75.

Sforzi, F. (1990), The quantitative importance of Marshallian industrial districts in the Italian Economy, in Pyke et al, *Industrial Districts and Inter-Firm Co-operation in Italy*, International Institute for Labour Studies, Geneva.

Sole, F. and Valls, J. (1991), Networks of technological co-operation between SMEs: strategic and spatial aspects, in Camagni, R. (ed.), *Innovation Networks: Spatial Perspectives*, Belhaven Press, London.

Stöhr, W.B. (1986), Territorial innovation complexes, in Aydalot, P.(ed), *Milieux Innovators en Europe*, GREMI, Paris.

Storper, M. (1992), Limits to globalisation: technology districts and international trade, *Economic Geography*, vol. 68, pp. 68-93.

Storper, M. (1993), Regional 'worlds' of production: learning and innovation in the technology districts of France, Italy and the U.S.A., *Regional Studies*, vol. 27, no. 5, pp. 433-455.

Storper, M. (1995), The Resurgence of Regional Economies, Ten Years Later: the region as a nexus of untraded interdependencies, *European Urban and Regional Studies*, vol. 2, no. 3, pp. 191-221.

Storper, M. and Scott, A.J. (eds) (1992), *Pathways to Industrialisation and Regional Development*, Routledge, London.

Thompson, C. (1988), Some problems with R&D/SE&T-based definitions of high-technology industry, *Area*, pp. 265-277.

Thompson, R. (1989), *The Path to Mechanised Shoe Production in the United States*, University of North Carolina Press, Chapel Hill.

Thompson, G., Frances, J., Levacic, R. and Mitchell, J. (eds) (1991), *Markets, Hierarchies & Networks: The Coordination of Social Life*, The Open University, London.

Tödling, F. (1990), *Raumliche Differenzierung betrieblicher Innvovation*, Edition Sigma, Berlin.

Trigilia, C. (1990), Work and politics in the Third Italy's industrial districts, in Pyke, F., Becattini, G. and Sengenberger, W. (ed.), *Industrial Districts and Inter-Firm Co-operation in Italy*, International Institute for Labour Studies, Geneva.

You, J.I. and Wilkinson, F. (1994), Competition and co-operation: toward understanding industrial districts, *Review of Political Economy*, vol. 6, no. 3, pp.259-78.

Wilkinson, F. (1983), Productive systems, *Cambridge Journal of Economics*, vol. 7, pp. 413-429.