Clusters, Innovation and Regional Development

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Abstract:[1]
This paper provides a critical examination of the widely disseminated view that innovation in all or most activities is favoured by certain common characteristics in the local 'milieu', involving a cluster of many small firms benefiting from flexible inter-firm alliances, supported by mutual information exchanges of both an informal and formal nature. The general applicability of this model, and the localness of crucial linkages, is questioned on the basis of a theoretical analysis of the innovation processes, and relations between actors and their environments, leading to the identification of a range of different hypotheses about the geography of innovation. Examination of new survey evidence from a large number of firms in the London conurbation suggests that the importance of informal information spillovers enabled by spatial proximity for successful innovation is much more limited than has been suggested, both in relation to wider agglomeration economies and to non-local business linkages.

Key words:

Innovation Agglomeration Industrial Clusters Innovative Milieux

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1. Introduction

Over recent years, the topic of innovation has received growing attention from urban and regional analysts. Much of the recent growth in interest in this issue has arisen in part out of a generally renewed interest in agglomeration economies, on the part of both economists (Krugman 1991) and business analysts (Porter 1990). This is because questions concerning the relationship between innovation and regional development have tended to focus on the role played by agglomeration economies in fostering localised learning processes within the economy (Glaeser 1999). In particular, informal information spillovers (Jaffe et al. 1993; Almeida and Kogut 1997) as well as the information transfers associated with local inter-firm labour mobility (Simpson 1992), are perceived to contribute to the creation of an environment in which the external net benefits of localisation more than compensate for any congestion costs associated with industrial clustering. These localised net benefits are often assumed to include the genesis of new products and processes, the initial development of which is perceived to be facilitated by geographical proximity (Saxenian 1994). These are crucial elements in the quality-based competition recognised by Porter (1990) as the key to national and regional advantage.

Apart from intellectual curiosity, the renewed interest in the relationship between innovation and regional development has also arisen due to the performance of a few key industrial clusters, so called 'new industrial areas' (Scott 1988), which appear to spawn a high degree of industrial innovations, such as Silicon Valley (Saxenian 1994; Larsen and Rogers 1984; Scott 1988), the Southern California electronics industry (Scott 1993), the Emiglia-Romagna region of Italy (Scott 1988; Castells and Hall 1994), and the science-based industrial cluster around Cambridge, England (Castells and Hall 1994). These industrial clusters are characterised primarily by a large number of small to medium sized firms, which generate a range of new products whose product life-cycles Vernon (1966) tend to be short. The clusters are focused in different degrees on the development of 'hi-tech' products and/or the technological upgrading of craft activities. Member firms appear to form ever-changing inter-firm alliances and coalitions in order to successfully innovate, depending on the information currently available within the cluster. Smallness is argued to provide flexibility in a firm's relations with other firms, thereby maximising the firm's ability to make the appropriate alliances for the duration of a project.

Observation of these industrial clusters has led to new discussions concerning the potential impacts of regional planning policies in the fostering of localised innovation and growth. However, much of the hypothesised role for regional planning in encouraging this growth is based on the behaviour of an idealised typology of an industrial cluster, characterised as an 'innovative milieu' (Aydalot 1986; Aydalot and Keeble 1988; Camagni 1995). The characteristics of this idealised type of an industrial cluster are many small member firms, which engage in mutual inter-firm information exchanges of both an informal and formal nature, the result of which is a high degree of flexibility in their inter-firm alliances. Proponents of this view argue that this particular form of industrial organisation provides the optimal environment for localised innovation and growth. Yet, from the point of view of innovation, there

is no inherent reason why this particular relationship between geography and industrial organisation should be systematically superior to alternative arrangements. The reason is that alternative forms of spatial and institutional arrangements are appropriate for different environments, and attempts at characterising an idealised typology of firm-industry-geography organisation which maximises innovation would appear to misunderstand the inherent features of innovation itself. It is quite possible that for many of those sectors where clusterisation is perceived to aid innovation, this particular spatial pattern had already emerged to a large extent for other rather different reasons.

The paper is organised as follows. In section 2 we begin by considering the nature of innovation, and from this discussion we develop our definition of innovation that we subsequently employ in the rest of the paper. In section 3 we explore the theoretical relationship between innovation, production and competition. Here we focus on two complementary approaches to these issues, one of which adopts a product-cycle model, and the second of which adopts an agent-environment model. On these basis of these discussions we develop five theoretical Working Principles which characterise the essential aspects of both the phenomenon and processes of innovation. In section 4, we then use these five Working principles in order to construct four Hypotheses concerning the nature of the relationship between innovation and geography. In section 5 we explain the different types of clusters concepts evident in the literature and identify the major features of each. This is important because only by doing this are we able to pinpoint the implicit assumptions which underlie many of the currently-popular concepts of industrial clustering. In section 6 we discuss both the aggregate results and the micro-econometric results arising out of surveys of the relationship between innovation and the London economy. Our overall results suggest that many of the fashionable 'innovative milieux' and 'new industrial areas' arguments, which promote the innovation advantages of industrial clustering on the basis of social-network theory, are largely misplaced, and that simple explanations of agglomeration economies generally suffice.

2. The Nature and Definition of Innovation

Defining innovation is itself a difficult problem (*The Economist* 20.2.99). The reason is that the term 'innovation' is frequently used in a variety of ways and contexts, many of which overlap and some of which are rather contradictory.

Innovation is different from pure invention. Innovation involves the successful implementation of a new product, service or process, which for most activities entails their commercial success. Distinguishing between product and process innovations is also a problem, in that one often leads to the other. One firm's new product is another firm's new process, and vice versa. New processes can allow new products to be developed, while the mass production of successful new products often requires process innovation. Also, new products, when they are consumed either as factor inputs or intermediate goods, can contribute to changes in the way other products are produced. Both sets of interactions on face value can be defined as innovations. The problems of distinguishing between product and process innovations therefore also lead to problems of interpreting innovation within an orthodox microeconomic framework. Identifying whether innovations are due simply to factor allocation

changes within existing production functional relationships, or alternatively due to changes in the production functions themselves can be problematic (Morroni 1992). Similarly, innovations may involve either or both price (Hirschleifer 1980) and non-price quality competition (Koutsoyiannis 1982). Understanding the effects of innovation on market conditions therefore requires identifying the specific effects of innovation on both production function and price-competition relationships (Beath and Katsoulacos 1991), because market outcomes will differ according to exactly how any particular innovation is manifested.

As well as the nature of innovation, identifying the sources of innovation is also a difficult problem. Some strands of research have focused on the nature and behaviour of the entrepreneur (Casson 1982), and investigated the extent to which entrepreneurial activities contribute to, or are dependent on, an innovative industrial environment. Other research has focused on the nature of the individual firm within an evolutionary, behavioural and organisational context (Nelson and Winter 1982; Williamson and Winter 1993; Pitelis 1993; Casson 1990, 1997). Processes of inter-firm competition, learning and imitation, may lead to periods of rapid innovation which lead to fundamental changes in the nature of economic activity (Nelson and Winter 1982; Solomou 1990) of a type first identified by Schumpeter (1934). However, both the origins and impacts of such innovations may be quite different between industrial sectors, geographical areas and time periods (Casson and McCann 1999; Piore and Sabel 1984; Best 1990). It is this heterogeneity of sources and outcomes which makes innovation difficult to identify and analyse (Dosi et al. 1987; Dosi 1988).

In spite of these problems we face in identifying innovations and isolating the nature, sources and impacts of innovation, we can conclude that there are three common features of all innovations which are identifiable; these are newness, improvement, and the overcoming of uncertainty.

Firstly, innovations are by definition changes in either or both the technical and technological relationships of a firm (Morroni 1992). An innovation will therefore alter the potential set of alternative blueprints (Stoneman 1983) available to a firm defining how a particular activity may be carried out. However, an increase in the number of alternative blueprints defining an activity is not of itself usually deemed to constitute an innovation. The reason is that secondly, the *new* blueprint must also be demonstrated to be superior to the existing alternatives, in that it must provide an *improvement* to the existing set of blueprints. Exactly, how blueprints are demonstrated to be superior is a problem in its own right, and from a spatial point of view is a crucial issue. Although, as we have seen, identifying the source of innovation is both difficult and beyond the objective of this paper, the process of verification of the superiority of a new blueprint can in some circumstances be related to geography. We will discuss this issue in detail shortly. Thirdly, the final common feature of all innovations is that they involve facing *uncertainty*, i.e. situations to which past experience seems to provide an inadequate guide, even as to the risks involved. This distinction between an environment of uncertainty and an environment of risk dates back to the work of Von Thunen and Knight, whereby the ability to handle situations of uncertainty is seen as the basis for the profits of the entrepreneur. Beyond the exercise of imagination, and the willingness to move outside established routines and heuristics, this task requires ways of establishing a new order, and

transforming situations of uncertainty into more calculable, manageable and insurable situations of risk. On the basis of this discussion we now have our first working principle on the nature of innovation.

Working Principle 1: *All innovations share three common features: newness, improvement, and uncertainty.*

This tri-partite definition of innovation as being any commercial activity which exhibits the simultaneous characteristics of newness, improvement, and uncertainty, provides the basis of our subsequent empirical analysis of innovation which we undertake in this paper. It is a much broader definition of innovation than is employed in much of the patent citation literature (Jaffe et al. 1993; Acs 2002). However, the advantages of this particular definition of innovation are twofold. Firstly, it can be applied equally to product or process innovations, and secondly, it can be applied to any industrial sector, irrespective of the levels of technology employed. This is important in that so much of the 'innovative milieux' literature overly focuses certain types of high-technology industries, and then attempts to generalise from these observations to all regions and all sectors. As we will argue in this paper, this approach is at best myopic, and at worst, entirely misleading.

3. The Relationship between Innovation, Production and Competition

Our adoption of the above tri-partite definition of innovation will allow for the examination of some of the ways in which industrial innovation is facilitated, or hindered, by geography. However, in order to clearly establish the relationship between geography and innovation based on our tri-partite characterisation, it is first necessary to clarify the two possible links which may underpin this relationship. These two links are the firstly, the link between innovation and product life-cycles, and secondly, the link between agents and their environments. In this section we will first discuss these two links, and then in section 4 we will employ the insights from these two potential links in order to develop testable hypotheses as to the relationship between geography and innovation.

3.1 Innovation and the Product Cycle

The capacity of a firm to innovate successfully is largely conditioned by its core technological and market expertise, and the relationship between this expertise and its current demands. Within this context, the analytical implications of the first two characteristics of all innovations, namely newness and improvement, can be understood by adopting the framework of the product life-cycle, in which a typical life-cycle runs from innovation through market saturation to obsolescence. This cycle, whether at the level of very precisely identified models, or more markedly at that of generic types or sets of products, involves a learning experience as producers discover what will sell and how to manufacture it economically, and consumers or users learn about the value of different combinations of product characteristics. This learning experience generally involves an increasing variety of characteristics, and possibly of production methods in the early phases, with a tendency thereafter toward a degree of standardisation on product ranges which can be made and sold in large numbers, leaving fringes of the market for niche producers offering distinctiveness at substantially higher prices (Markusen, 1985). In this life-cycle process, quality

competition increasingly gives way to price competition, or rather value-for-money competition, since assurance of appropriate quality standards of conventional kinds is an important part of the equation (Vernon, 1966). This implies a reduction in the rate and the significance of product innovation, and of some kinds of process innovation too, although shifts in the scale of production during the growth phase provide new stimuli to this, as may the pressure of price competition associated with standardisation, new entries, and market saturation. For Utterback and Abernathy (1975) the peak rates of process innovation actually materialise rather late in the cycle, when the pressure increases for achieving cost-reducing productivity growth. However, this seems to ignore more fundamental kinds of process innovation stimulated earlier in the learning curve, as the scale of production shifts.

Within any sector as a whole, there are both more and less profound forms of product innovation, differing both in the degree to which they render established products, skills and production facilities obsolete, and in the time period over which they can be expected to yield profits.

For example, within the motor industry, annual model changes may be nested within more generic shifts in vehicle type, and within the car itself as a form of personal, motorised mobility. Some at least of the more specific changes represent adjustments to, or attempts to manipulate, more or less transient shifts in taste rather than some more durable form of learning about what is wanted and how it can efficiently be produced. As an industry matures, these are likely to become a larger part of product innovation, subject to the constraints of established production processes. In production sectors a more flexible economy entails a greater degree of adaptability of this kind with production processes in mature sectors being modified to facilitate both variability and tactical innovations in product characteristics, as well as an expansion of the role of niche producers whose methods remain those of the earlier phases of the cycle.

On the other hand, some sorts of activities oriented to fashion markets, and/or activities where it is hard to separate product characteristics from those of the production process, have always been in this sort of situation, with relatively constant rates of innovation. Their epitome may be found in the creative service sectors, where every production is to some degree a one-off innovation, although not always reported as such, since it is normalised in the procedures of the activities involved. So, it might be argued, is it also the case in those capital intensive activities such as pharmaceuticals which are substantially self-sufficient in R&D, relying on the scale of their activities to transform the uncertainty of innovation into acceptable levels of risk.

The crucial differences between the characteristics of innovation in each of these cases is in terms of the time-scales of their respective product cycles and also in terms of extent to which these innovations represent fundamental or marginal changes to existing sets of blueprints. Yet, comparing, evaluating or ranking these individual innovations is very difficult. Such comparisons can only genuinely be determined via observation of the commercial advantages generated by such innovations to the firm or the society. In situations where an invention is patented, the inventing firm's profits, plus any royalties generated by imitation, will be the most accurate guide to the private value of the innovations. However, even these measures will tend to underestimate the true value of the innovation if the innovation is embodied in an intermediate input to other sectors. On the other hand, in situations where externalities

or public goods predominate, such measures may either not be possible at all, or alternatively where they are possible, they will significantly underestimate the true economic value of the innovation. Therefore, in our definition of innovation, a key feature of innovation must often be the self-perception of the firms, in that it is they who identify whether such changes exhibiting these three features have actually taken place or not. Yet, this self-perception cannot be entirely introspective, in that self-perceptions of the firms are themselves dependent on interpretative activities of the particular commercial community in which they operate. In the case of patenting, it is the legal and scientific community which provides this communal interpretation, whereas in situations where innovations are not patented, it is the business community and the market which provides this interpretation. As such, innovation is not simply about technology and the ownership of proprietary information advantages, but also about the application of either private or public information.

On the basis of this discussion we therefore now have our second working principle on the nature of innovation.

Working Principle 2: *Unless legal property rights can be well defined via patenting, the importance of individual innovations cannot be ranked.*

As we have seen, the ability to rank innovations is impossible for most service and process innovations, and as such, the relative extent to which a new activity or outcome is an improvement on previous modes of activity cannot be determined.

3.2 Agents and environments

The third feature of all innovations is that they involve the overcoming of uncertainty, within a process by which competing agents attempt to move from an environment of uncertainty to an environment of somewhat measurable risk. The analytical and empirical implications of this third characteristic of all innovations can be described by adopting the agent-environment framework of Alchian (1957). Alchian's argument is that the behaviour of firms in conditions of uncertainty can be understood by discussing the relationship between a firm and its environment, whereby a firm's environment is understood to encompass all the agents, information, and institutions competing and collaborating in the particular set of markets in which the firm operates. In order to understand how firms cope with uncertainty, in Alchian's schema, we must characterise the uncertain economy by two broad types of environments. One is an 'adoptive' environment and the other is an 'adaptive' environment. These two classifications are not mutually exclusive, but serve as stylised polar cases, between which the real economy will exist.

In the 'adoptive' environment, all firms are more or less identical in that no firm has any particular or systematic information advantage over any other firms. The results of the competitive process will imply *ex post* that some firms will be successful while others will not, although *ex ante*, no firms had any a priori knowledge that their products or techniques would be superior to their competitors. This characterisation of the economy is Darwinian, in that the environment 'adopts' the firms which were better suited to the needs of the economy, even though the firms had no particular knowledge beforehand that this was the case. Although perfect competition is Darwinian, Alchian's 'adoptive' environment is probably best

understood as something akin to monopolistic competition, in which there are many small firms, all of which are slightly different, but which share many common features in terms of technology, entry and exit freedom, and a lack of any significant individual market power or market information. In statistical terms, in any given time period, the probability of successful innovation by any single firms is identical to that of all the other firms.

In the 'adaptive' environment, some individual firms are able to gather and analyse significant market information, simply by reason of their size. Large firms in general are able to utilise resources in order acquire and process information relating to their market environment. Moreover, the express purpose of these information gathering activities by the firms is to subsequently use the information to their own advantage, relative to their competitors. This is done by using the acquired information to inform the product and process decisions of the firm, thereby incorporating learning processes into the decision-making capability of the firm. This type of behaviour is termed 'adaptive' behaviour by Alchian, and the argument here is that in uncertain environments, the ability to gather and assimilate information increases the ability of the large market-leader firms to maintain their dominant position, relative to smaller firms. In statistical terms, in any given time period, the probability of a firm making a successful innovation is increased by reason of its size.

This Alchian agent-environment framework now allows us to describe the process by which firms cope with uncertainty, or more particularly, the process by which firms move from an environment of uncertainty to an environment of somewhat measurable risk. This process is strongly influenced by the models which are available to each firm for dealing with new situations. For example, the perceived level of uncertainty (and its traumas) are maximised where the agent's available experience is dominated by only one or a few past models of normal situations and their management. On the other hand, the availability of a wider range of examples from which analogies can be drawn eases the firm's task, while confidence also benefits from a habit of having to face uncertainty or having to the resources of a large organisation. Where such experience or resources are not internal to the firm or agent, the impacts of uncertainty tend to be minimised where directly imitable models are available. In particular, smaller firms which perceive themselves to be less able to systematically 'adapt' to their environments may follow the behaviour of the larger firms, making decisions which mimic or dovetail with those of the larger firms, in matters such as styles, protocols, formats and technology. The reasons for this type of leader-follower behaviour are that the smaller firms perceive themselves to be at a relative information disadvantage to the larger firms, and lacking in the power to impose new conventions on the market. Therefore, by copying the behaviour of the larger firms the small firms perceive that they will maximise the likelihood of their own success. In part this is because they perceive the market leaders to be the best barometers of market conditions, and also because the behaviour of the market leaders itself often contributes significantly to the economic environment simply by reason of size. The result of this type of behaviour is that all firms in the economy attempt to transform uncertainty into risk. Large firms tend to overcome uncertainty by information gathering and analysis, and small firms tend to overcome uncertainty by imitation.

The implication of this Alchian line of argument, is that the number of successful outcomes which accrue to firms which had not imitated market leaders is much less than those than which accrue to firms which had imitated market leaders. Moreover, in order for firms which do not follow accepted industry behaviour to achieve successful outcomes, the nature of their activities must be fundamentally different from existing market behaviour in order for them to be attractive. In part this is because the environment is itself largely being determined by the decisions of the market leaders. Also, however, as we have already seen, the determination of whether something is good or not is itself subject to institutional and social behaviour, frequently requiring an interpretative community of firms or consumers. To a large extent these firms are sailing against the prevailing market winds, and in order for them to be successful, they need to appeal to the interpretative community in a radically different manner than existing accepted products or practices (Nelson and Winter 1982; Dosi 1988). On the other hand, for the majority of firms who do not adopt radically different paths, successful outcomes tend to be generated by the similarity of behaviour. However, Alchian's argument does not imply that that all the behaviour of the economy is uniquely determined. From the 'adoptive' environment, we know that some of the ex post outcomes within the economy are randomly determined. Given that the real economy is a mix of both 'adaptive' and 'adoptive' environments, and that this mix will differ between sectors, some of the successful market outcomes will be generated by firms which, ex post, did not imitate the behaviour of the market leaders.

If economies of scale and technological 'lock-in' (David 1985; Arthur 1994; Lewin 2002) effects operate within the economy, Alchian's leader-follower behaviour will also engender path dependent effects within the market, which will tend to reinforce the imitation behaviour. This will lead to the development of industry standards, accepted practices, and institutional rather than purely individual firm behaviour. Moreover, even where firms which are taking radically different paths are successful, to the extent that lock-in effects operate within the economy, these newly successful firms will also contribute to the generation of new path dependent effects which are distinct from those already evident in the economy.

The implications of these lines of argument for our understanding of the relationships between innovation and uncertainty are quite straightforward, in that innovation is simply any new product or process development which is shown to exhibit ex post a commercially successful outcome. Within this framework we can therefore now construct three more working principles as to the nature of innovation:

Working Principle 3: *Innovation behaviour may itself be somewhat path dependent, with innovating firms still tending to follow particular technological and social trajectories.*

Working Principle 4: *The number of successful innovations which accrue to firms which had not imitated market leaders, is much less than those than which accrue to firms which had imitated market leaders.*

Working Principle 5: *Although fewer in number, the innovations produced by firms which had not imitated market leaders will tend to be more fundamentally new and*

different to the innovations originating in the majority of firms which do imitate the market leaders.

Taken together, our five working principles developed on the basis of theories of innovation suggest that all innovations share three common features, namely newness, improvement, and uncertainty. However, unless legal property rights can be well defined, the importance of individual innovations cannot be ranked. Having said this, there are several aspects of innovation which are identifiable. Firstly, innovation behaviour may itself be somewhat path dependent, with innovating firms still tending to follow particular technological and social trajectories. Secondly, the number of successful innovations which accrue to firms which had not imitated market leaders, is much less than those than which accrue to firms which had imitated market leaders. Thirdly, although fewer in number, the innovations produced by those firms which had not imitated market leaders will tend to be more fundamentally new and different to the innovations originating in the majority of firms which do imitate the market leaders.

For our purposes, what is important is that each of these characteristics of innovation and the innovation process can be argued to have direct parallels in economic geography. Imitation in the face of uncertainty is regarded by location theorists (McCann 2002) as a rationale for industrial clustering, and path dependency is regarded as providing for the continued existence of clustering, via agglomeration behaviour (Arthur 1994). As such, industrial clustering and innovation would be expected to be correlated. More specifically, the location of key institutions or firms would be expected to act as a catalyst for much of the observed clustering and innovation behaviour. Finally, the radical nature of some innovations implies that at certain junctures, quite different locations will emerge as being advantageous in terms of innovation. However, these geographical changes would not be expected to be smooth or continuous, but rather somewhat discontinuous. Whether or not these various arguments can actually be substantiated is still an open question. Yet, we are now in a position to begin to investigate the various possible relationships between innovation and geography. In order to do this, in the following section we will endeavour to answer some of these issue by developing a set of four hypotheses as to the possible relationships between geography and innovation, which will then allow for some empirical testing in the subsequent sections.

4. Hypotheses about the Geography of Innovation

From the consideration of the economic nature and processes of innovation set out in sections 2 and 3, a large number of hypotheses can now be developed to account for the widely observed uneven spatial distribution of innovative behaviour (Sternberg, 1996). At a rather broader level they can be seen to involve four quite distinct sorts of approach to explaining that geography. The first two of these stem from the product cycle model described in section 3.1, while the second pair relate in different ways to the interaction between agents and their environment described in section 3.2.

Hypothesis 1: *The contemporary geography of innovation is essentially a geography of the currently more innovative sectors of the economy*

This hypothesis takes off from the observation that in any period there are some sectors of economic activity which will be more heavily involved in innovation of products or processes than others. This may be because of the particular phase which has been reached in the life cycle of their product set, or because some activities with very short product cycles are more or less permanently locked into the innovative phase. If each of these industries is subject to rather different location factors, because of the nature of their production technologies and/or of marketing/consumption process, the geography of innovation may then be reducible simply to a geography of industrial location. With activities remaining in the same broad locations through all of the phases of the product cycle, places which they dominate will also appear to move through that cycle, except for the homes of the permanent innovators, which would remain continuing sites of innovation.

Hypothesis 2: *The contemporary geography of innovation is essentially a result of sectoral differences in the phases of product or profit cycles.*

This alternative interpretation of the product cycle geographies emphasises significant and typical shifts in the locational requirements between the phases of an industry's product or profit cycle. In particular, Markusen (1985) has explored the spatial implications of qualitatively changed conditions of production and demand during the course of the cycle, emphasising the particular role of agglomeration economies during the innovative phases of an industry's product cycle. From this perspective, during these early innovative phases, neither the scale of production nor the certainty of growth are sufficient for firms to attempt self-sufficiency either in production or training, while design uncertainties also militate against reliance on either distant suppliers or semi-skilled labour. In this early phase, access to appropriate skills and sub-contractors are a crucial condition for successful innovation and the management of uncertainties. Later on, in the mature phases of the cycle, when output scale has been achieved, production methods have become routinised, and cost factors are increasingly important, both simple geographical dispersal to lower cost locations and the spatial division of labour, will become increasingly relevant.[2] From this perspective, therefore, what is generally significant about the geography of innovative activities is not the distribution of creative or inventive potential, but the production conditions which allow infant firms and industries to survive and thrive in a nursery environment, until they acquire the scale and experience to strike out on their own.[3]

In terms of the assumptions underlying the relationship between innovation and geography, there is a fundamental difference here between the first and the second hypotheses, both of which are developed on the basis of the product-cycle model. The first hypothesis works on the assumption that as innovation takes place, the innovating firms are primarily static in terms of their location behaviour, such that different phases of the product-cycle are not reflected in changing industrial geographies. On the other hand, the second hypothesis works on the assumption that

[2] This process may be slowed and such spatial decentralisation delayed or avoided by successful 'oligopolisation' of particular sectors, which increases the likelihood that industries are born, mature and die in the same locations, as is assumed in hypothesis 1.

[3] Duranton and Puga (2001) in their life cycle model emphasise diversity as the key requirement of nursery environments in which firms introducing new products have access to an array of models of production processes to borrow and try out, before routinising and relocating to more specialised cities.

the innovating firms are largely dynamic in terms of their location behaviour, such that the different phases of the product-cycles are indeed reflected in terms of evolving industrial geographies.

Hypothesis 3: *The contemporary geography of innovation is essentially the outcome of variations in the characteristics between different places which lead to differences in the geography of creativity and entrepreneurship.*

This third approach to understanding the distribution of innovative activity focuses on the geography of creativity and entrepreneurship, in the sense of place characteristics favouring the development and commercial launching of potentially successful new or improved products, either through established or new business organisations. The emphasis here is on the factors which stimulate and enable novel developments while also facilitating the selection of those with real competitive potential. The three key sets of factors involve:

(i) a rich 'soup' of skills, ideas, technologies, and cultures within which new compounds and forms of life can emerge;

(ii) a permissive environment enabling unconventional initiatives to be brought to the marketplace; and

(iii) vigorously competitive and critical arenas operating selection criteria which anticipate (and/or shape) those of wider future markets.

In some circumstances, particularly when the driver is patentable scientific knowledge which can be profitably produced and exploited in-house, the relevant environment may be primarily that of a global business corporation. More typically it is likely to be a place (locale, city or region) with the "unique buzz, unique fizz (and) special kind of energy" coupled with discretionary spending power, which Hall (1999, 963) sees as the critical magnets.

Two aspects of this fertile environment highlighted by Chinitz (1961) in his classic comparison of New York and Pittsburgh are the minimal requirement that new enterprises can combine relevant technical and market expertise, and the lower likelihood of meeting this in an urban economy dominated by large bureaucratic businesses. From a different perspective, Porter (1990) also highlights some of these factors in arguing for the importance of both a discriminating local market and rivalry among local producers within a particular sector as spurs to quality improvements in their goods or services.[4] With this preferential local transmission of information, the Alchian leader-follower model provides the basis both for the local contagion of innovation from leading firms, and also for mobility of followers to cluster around leading innovators.

[4] These hypotheses all relate to the innovative behaviour of typical local firms, although a dynamic environment may also attract to it mobile investment from businesses seeking a conducive environment for an innovation-based growth strategy.

Hypothesis 4: *The contemporary geography of innovation is essentially a result of the fact that innovation is most likely to occur in small and medium-sized enterprises, whose spatial patterns happen to uneven.*

This fourth approach to explaining the uneven geographical patterns of innovation involves another type of 'milieu' argument, which is focused on the geography of co-operation. In common with the two previous approaches, this rests on the perception that innovation is most likely to occur in small and medium-sized enterprises, which have neither the scale nor the risk-bearing capacity to provide all of the key inputs on their own account. Observations from so-called 'new industrial districts' (Scott 1988) such as Silicon Valley (Saxenian 1994) and the Emilia-Romagna region of Italy (Scott 1988; Castells and Hall 1994) have suggested that the geographical proximity of SMEs is a necessary criterion for the development of mutual trust relations based on a shared experience of interaction with decision-making agents in different firms. In these contexts, the social network model (Granovetter, 1973, 1985, 1991 and 1992) has highlighted the role of social as well as purely instrumental business links. This emphasis on small firms may be questioned, and a line of argument going back to Schumpeter (1942) has pointed to the crucial role in modern times of big firms' R&D. However, among smaller firms it is still an important fact that they are particularly reliant on external economies of agglomeration as a substitute for internal economies of scale. Where active risk-sharing is involved, however, pure agglomeration of self-interested individuals does not ensure the relations of trust and restraints on opportunistic behaviour, required when contracts and market flexibility offer inadequate protection for agents' interests. Trust of this kind requires a combination of inside information about competences and dispositions, about whose capacities can be relied on or not, and forms of social control which penalise breaches of a community's business norms. It can be seen that there is some tension between these requirements and those highlighted by the previous approach, since both inside information and social control will tend to be maximised in rather conservative, static activities and regional economies. For innovation, the key features of trust relations are a confidence in the competence of collaborators to operate in an innovative environment, and absence of fear of reprisals after any reorganisation of inter-firm relations. Tighter forms of social control than these are likely to be inimical to innovation (Rodriguez-Pose, 1999). However, spatial clustering is neither a necessary nor a sufficient criterion for the development of trust relations. Meanwhile, not all trust relations are supportive of innovation. As such, the relationship between innovation and trust relations appears rather ill-defined.

5. Clusters and the Geography of Innovation

Within the industrial economics and international business literatures, most of the thinking on innovation is dominated by Hypotheses 1 and 2. However, within management science, economic geography and regional planning, the overwhelming wisdom concerning the relationships between innovation and geography is dominated by Hypotheses 3 and 4. The reason for this is that these fields have been driven by two immensely popular and interrelated literatures, namely the literature on 'innovative milieux'/'new industrial areas' (Aydalot 1986, Aydalot and Keeble 1988; Scott 1988), and the Porter (1990) literature on industrial clustering, both of which implicitly assume Hypotheses 3 and 4 to be *demonstrably true* rather than simply hypotheses. In these literatures, many qualitative aspects of the local technical and

business environment which are apparently associated with more successful innovation have been highlighted, drawing particularly on examples from outside the established metropolitan regions. The central hypothesis of this work, is that the sub-regional clustering of related activities, has the potential, if suitably encouraged, to generate stronger social networks between businesses, which would promote successful innovation and competitive advantage. These literatures are therefore of great interest to policy-makers, even without any empirical substantiation, because they appear to hold out the possibility of simultaneously boosting the prospects of non-central areas as well as that of the national 'competitive advantage', simply by mimicking the positive qualities to these apparently innovative areas. Yet, conceptually this literature (Saxenian 1994; Keeble et al. 1999; Keeble and Wilkinson 1999; Porter 1998 a,b) relies crucially on the validity of an implicit synthesis between theories of innovation, social network theory and spatial industrial clustering. Therefore, in order to assess the extent to which such theories of innovation geography are useful it is necessary to ask under which conditions this synthesis is justifiable and under which conditions it is not.

To do this, it is essential to note that none of the four innovation-geography hypotheses set out in section 4 are entirely specific about the spatial scale or scales at which key innovation factors or processes operate. The example of the creative service or financial districts within cities suggest the relevance of a very local geographical focus may be appropriate, whereas the new industrial districts literature suggests an emphasis on the inter-urban and regional scale of analysis.[5] For multinational firms, the critical geographies for innovation may extend over large regional, interregional or even international scales (Cantwell and Iammarino 2002). These differences may be a result of the fact that the critical spatial area within which different mechanisms associated with innovation operate may be different for different activities. For example, the critical spatial scale for labour market job-matching purposes may be rather different to the critical spatial scale over which informal information spillovers operate (Angel 1991), reflecting different kinds of spatial process which foster or hinder innovation. As such, the relevant spatial scale at which to which to explain and plan for innovative activity is liable therefore to vary greatly between activities. Similarly, the critical spatial scale within which innovation processes operate may be different for different types of industrial clusters. This suggest that the relationship between geography and innovation actually depends on the nature of the information interactions which take place within particular types of spatial-industrial structures.

In order to compare the different types of industrial clusters types possible, as we see in Table 1 Gordon and McCann (2000) have employed a transactions-costs framework in order to contrast the *social network model*, where agents invest significant efforts in creating or maintaining their local business networks, with two alternative models of spatial clusters: the *industrial complex,* where a closed set of partners rely on exclusive and stable contractual relations; and the *pure agglomeration*, where sheer numbers of potential interaction opportunities enable and encourage more opportunistic and shifting combinations of businesses. For our

[5] On the other hand, Silicon Valley is much larger than Europeans tend to suppose, and evidence from joint-ventures and alliances suggest that the effective spatial scale of co-operation for semi-conductor firms in that region is actually closer to that of the state of California, which is rather larger than many industrial nations (Arita and McCann 2000; Suarez-Villa and Walrod 1997).

purposes here, what is important is that the critical relationship between geography and information flows for each of these particular cluster types is quite different. The pure agglomeration geography is an urban area, the industrial complex geography is local but not necessarily urban, and the social network geography is regional. Therefore, the critical relationship between innovation and geography will depend on:

(a) which type of spatial-industrial organisational arrangement is most prevalent in the economy, and:

(b) what is the critical relationship between geography and innovation in the arrangement described in (a).

In previous research on the London economy (Gordon and McCann 2000) the pure agglomeration model was argued to be the most generally relevant basis for the London-based industrial clusters, most notably, although not exclusively, within the core metropolitan areas. On the basis of Hypotheses 2, 3 and 4, we would expect that in London the phenomenon of agglomeration should therefore also be very strongly linked with innovation.[6] Certainly at an empirical level, the association between innovation and agglomeration is a very familiar one (Hall 1999). This association is broadly consistent with standard arguments about the role of external scale economies in ensuring access to the latest market information, the highest quality labour skills, and the most appropriate specialist suppliers, all vital to new product or process developments. These all provide means of allowing innovating firms to minimise their own commitments when entering uncertain new markets. The required skills and services themselves are made available because in an agglomeration with large numbers of independent enterprises, the effects of random asymmetric shocks can be reduced to calculable and acceptable levels of risk (Mills, 1980). From the Alchian leader-follower perspective, the availability of local paradigms of successful innovation may also enable many more firms in these areas to innovate in less radical ways without crossing their threshold of acceptable uncertainties, and also to encourage such firms to locate there. For leaders also, spatial industrial clustering can provide a critical support, in the form of an interpretative community of networks of discriminating customers and distributors as well as designers and producers who are able to draw on national and international channels of information in order to verify the technical and potential commercial superiority of new products or processes. Traditionally these verification features have been strengths of the highest order central places with their diversely specialised economies, rich external connections, and affluent avant-garde consumers.

While the pure agglomeration model appears to be the most appropriate characterisation of the London economy, it is evident, however, that not all urban metropolitan centres necessarily possess or retain the types of advantages described above relating to innovation, and this is particular apparent in the case of product innovation. Nor, from the clusters (Porter 1990) and new industrial areas (Scott 1988) literatures, which both based implicitly on the social network model, is it clear that the urban area is primarily the critical spatial unit of analysis in many cases of innovation.

[6] If the relevant aspects of trust for innovation are as we have just suggested, it may even be that agglomerations, for all their evident lack of continuity in relations, actually have an advantage in this respect.

The problem here is that none of the individual hypothetical relationships between geography and innovation, defined here by Hypotheses 2,3 and 4, specify the critical geography dimensions over which any links between innovation and geography operate. Therefore, in order to investigate these issues further, we once again focus on the case of the London region, and attempt to identify whether the link between agglomeration behaviour and innovation can be substantiated.

6. Case Study: Innovation Behaviour and Location in the London region

As home to the UK's most obvious concentrations of innovative activities, together with many of the conditions expected to favour successful innovation, the London region provides an interesting case study of how these spatial factors may matter. The wider London regiont boasts the most highly qualified labour force, the best international links, the closest access to key decision-makers and elite discriminating consumers, the three premier research universities (London, Oxford and Cambridge), an array of key public sector research establishments, and an unrivalled agglomeration of specialist producer and cultural services. Unsurprisingly it is also an expensive region in which to do business, as a result directly or indirectly, of high space costs, and depends for its competitiveness on being able to offer products which are of distinctly higher quality or products which are not yet available elsewhere, whether because of their degree of specialisation or their novelty. These generalisations apply at various different spatial scales, most conspicuously in relation to the 10 square miles or so of central London, but also across the Greater South East (GSE) - some 150 miles across, from Cambridgeshire in the north east, to Dorset in the south west, and around the south east coast – identified by Hall (1989) as the effective functional region for London. Within this broader region, there are a series of sub-regions (including Cambridge, Hertfordshire and the Thames Valley-M4 corridor) which display some of the characteristics in a heightened form, though with rather more limited local accumulations of skills, information sources and services than central London.

6.1 Empirical Analysis of Innovation across the wider London region

If we take as a measure of innovative performance the proportion of businesses claiming (in the European Union's 1996 Community Innovation Survey) to have introduced new products or services in the previous 3 years, it is the broad GSE region *outside of London itself*, which displays the strongest incidence of innovation. London's own performance is around the national and European averages, but that in several other parts of the region is conspicuously higher. Moreover, this finding applies to manufacturing as well as service activities. In the first case, 12 of the 14 counties of the region figure among the top 25 in the UK. The top 8 include the 7 contiguous counties in the north and west of the GSE with between 68 and 80% of the sampled firms claiming new products, compared with 51% in London and 59% for the UK as a whole (Simmie and Sennett, 1999). For manufacturing, the pattern of intra-regional variation broadly reflects the locational distribution of the more innovative sectors. For services this is less obviously the case. In the case of services, where the differences are less striking and the sample less good, 8 of the GSE counties appear among the top 12. However, in this case the strong performers include several of the south coast counties, and are therefore distributed more randomly around the region. This general picture has also been confirmed by

observations of many other innovative cities such as Paris and Stuttgart (Simmie 2001).

This empirical evidence provides us with our first observation concerning the geographical nature of innovation.

Observation 1: *In the case of major urban regions, innovation is not primarily constrained to the urban area, but appears to be distributed across the hinterland areas of the urban centres.*

This regional, rather than specifically urban, pattern of innovation may reflect combinations of several factors. One of these is that several of the key assets are themselves regionalised, rather than being heavily concentrated in the urban core. For example much of the region's highly qualified labour pool actually lives in London's commuter hinterland, especially on the western side of the city, while most of the significant public sector research establishments are also found in this part of the region (and few actually within Greater London). The accessible commuter pool is maximised from sites within central London close to mainline termini (as may be true of other regionalised assets) but outside this prime rent area London's advantages are less clear-cut, and second-best sites may well be found within the commuter ring. Access to international air services - principally through Heathrow airport on the western boundary of Greater London, and secondarily through Gatwick in the south of the outer metropolitan ring – is also better from much of this 'western crescent' area than from most of Greater London. Even for those people and firms not based there, central London remains a natural meeting ground, and a key location for exchange (and interpretation) of intelligence from national and international networks. But for locational decision-making or the establishment of competitive advantage, a crucial consideration is the frequency with which staff need to be involved on a face-to-face basis in such interaction, and the trade-off between time spent in the required travel and the space/congestion costs associated with central locations. Clearly this varies greatly between different kinds of innovative activity, depending on the range of contacts on which they draw and the rhythm of their innovation/development cycles. However, very few other sectors have the same need for the type of up-to-the minute intelligence required for financial market operations, or the sheer frequency of meetings with external national-level (or foreign) contacts which are essential in much of the producer service or political activities. For many innovative activities which are heavily dependent on agglomeration economies, regional locations are therefore likely to be the preferred options. In addition, there is the possibility that more local externalities may be achieved through clustering of related kinds of business at a sub-regional scale.

Drawing on a number of studies of innovation in the London region by Simmie and colleagues and parallel work in the Paris region, Simmie and Sennett (1999) suggest that leading regions such as the wider London region are characterised by "multiple clusters of innovative sectors, mostly low levels of linkages with local suppliers and customers, the importance of national and international markets, critical infrastructure such as international hub airports, large size and high concentrations of competitive innovation" (p.89). This picture was confirmed with a survey of innovative firms' reasons for location within the wider London region in which the highest importance was given to traditional agglomeration economies, notably general issues of accessibility, premises and the

availability of professional labour, with secondary importance being given to local industrial knowledge, experience and suppliers. They conclude that innovative firms in such regions are gathered there together "not so much because they need or use strong intra-industry networks or linkages, but rather because they are making use of the multiple 'pick and mix' possibilities provided by the urbanisation effects of large urban agglomerations" (p.92).

These various explanations for the reasons why the wider London region is a leading area of innovation are exactly the standard Marshall (1920) arguments in favour of the agglomeration advantages of London (Gordon and McCann 2000). Therefore, this evidence provides us with our second observation concerning the geographical nature of innovation:

Observation 2: *In the case of major urban regions, innovation advantages can be explained largely in terms orthodox agglomeration effects.*

This observation appears to provide support for Hypothesis 3.

In the case of the London and Paris regions, these observations cast doubt on the significance of much of the clustering, innovative milieux or new industrial areas literatures, in that they suggest that the geography of innovation in these major urban regions can be understood simply in terms of orthodox explanations of agglomeration economies, without recourse to these various stylised constructs. The only spatial issue on which the simple agglomeration model would need to be modified is in terms of the critical spatial dimensions over which such agglomeration advantages to innovation appear to operate. Whereas a strict interpretation of urban economics would define the critical spatial area over which agglomeration externalities would operate as being the metropolitan urban area, it appears from Observation 1 that the innovation benefits of agglomeration may be rather more dispersed around the urban hinterland regions.

6.2 Empirical Analysis of Innovation within Metropolitan London

Within Greater London itself, a substantial amount of data on innovative activities and their characteristics is available from the 1996 and 1999 rounds of the London Employer Survey (LTC, 1997, 2000).[7] The aggregate raw statistics are reported in Tables 2 and 3. Overall in the 1996 survey, which provides the fullest information, and as we see in Tables 2 and 3, 47% of private business establishments claimed to have significantly extended or developed their products and services during the past 2 years, and 35% to have significantly developed their processes. But in both cases innovation was much more likely among larger businesses, so the two kinds of innovating establishments included respectively 58% and 50% of private sector employment in London. Within these innovating firms we may make a rough distinction between leaders and followers on the basis of firms' judgements about where they stood in relation to major competitors after their innovation. For both product and process innovation, a rather small proportion (around 5%) thought they were still left behind by some major competitors, with most either feeling that they

[7] A particular advantage of this source is the large number of respondents, including upwards of 3000 private sector establishments, the great majority of them in service activities poorly covered in sources more directly focused on innovation, such as the Community Innovation Survey (with about 750 service sector respondents across the UK).

had kept pace, or had achieved a (moderate or powerful) competitive advantage. On this basis, the leaders appear to be significantly larger than the followers (Table 1), while London seems to have a rather larger share of leaders in product than in process terms (accounting for 57% and 52% respectively of jobs in innovating establishments. Among those establishments which have not innovated, between a third and a half did not believe this was important for companies in their line of business. For process innovations in particular, those who recognised their importance but had made none recently tended to be smaller, single site, single or family-owned businesses.

The available evidence therefore provides us with our third empirical observation concerning the nature of innovation:

Observation 3: *Within innovative urban areas, larger firms appear to more likely to innovate than smaller firms.*

This observation appears to refute Hypothesis 4.

This observation is therefore also at odds with most of assumptions underlying the clustering, innovative milieux or new industrial areas literatures. However, it is entirely consistent with the Alchian framework discussed in section 3.2.

Within London, the highest rates of product innovation in 1996 were reported in printing/publishing, information/communications technologies (ICT), and recreational/cultural services, while process innovation was most common in City financial services[8], and ICT. Focusing solely on the 'leaders' (i.e. those claiming some competitive advantage after their innovation), ICT retains its position in respect of product innovation, although 'followers' predominated among the innovators in recreation/cultural services. Manufacturing as a whole, wholesale distribution, non-air transport, City financial services and (private) health care also had above average proportions of 'leaders'. In relation to process innovations, the above average performers were printing/publishing, air transport, City financial services, and ICT. Some significant spatial variations were also evident within London, with around 60-65% of jobs in parts of inner London (outside of the central area) and in the outer west (around Heathrow) were accounted for by innovating businesses (including 40-45% in 'leaders'), while in the outer east and centre the proportions were somewhat lower, with around 50% overall, and 20% for the leaders, respectively. For product innovations in particular, the strength of relations with both suppliers and customers was a significant factor favouring innovation. Among London firms, however, the probability of such links is not at all increased by having more local customers or suppliers. Nor overall is it the case that those businesses perceiving any kind of advantage in locating close to related businesses[9] are any more likely to innovate, either in products or processes.

Observation 4: *Within an urban area, the innovation advantages of an urban location appear to be explained largely in terms orthodox agglomeration effects, although the evidence points more to the influence of urbanisation, rather than localisation effects.*

[8] as distinct from the more routine operations elsewhere in London.
[9] These are actually a rather small minority among London businesses (Gordon and McCann, 2000).

This observation appears to provide support for Hypothesis 3.

Taking firms' perceptions of the rate at which the overall market to which they catered was growing or declining as a proxy for position in the product or profit life-cycle, it is clear that the innovative behaviour in London is associated with the early phases of that cycle. This is particularly true for product innovators, and especially for leaders 34% of whom were in the phase of the cycle with rapid market growth. But, contradicting Utterback and Abernathy's (1975) hypothesis, it is also the case for process innovators (Table 3). This did not, however, entail a particularly strong concentration of innovation among the most recently established enterprises in that the overall rate of product innovation was actually below average for firms founded in the previous 2 years, while three quarters of the leader establishments were from firms which were over 10 years old. This empirical evidence provides us with our fifth observation concerning the geographical nature of innovation:

Observation 5: *While innovation within the urban area is associated with early stages of the product or profit life-cycle, innovation appears to be more associated with older rather than newer firms.*

This observation appears to refute Hypothesis 2, and provides rather more support for Hypothesis 1.

The evidence presented so far based on our aggregate empirical data provides broad support for Hypotheses 1 and 3, and tends to refute Hypotheses 2 and 4. However, in order to further investigate these issues we conduct some micro-econometric analyses on the sample of London firms. Multivariate analyses of the probabilities of innovation using results from the 1999 survey showed a range of statistically significant influences, including (in rough order of importance).[10]

- industrial sector: after controlling for other influences, innovation is significantly less likely in construction, hotels, land transport, real estate, and (non IT) business services, while IT and food manufacture are the most significant innovating sectors;
- establishment size: innovation is substantially more likely in larger than small or medium sized establishments;
- stage in the product life cycle: innovation was most likely in the first phase (strong growth) and least likely in the last three (stability or decline);
- market area: innovation is substantially less likely among businesses whose main market is local to London districts, and more likely among those primarily serving national or European markets;
- establishment role: innovation was most common at the main site of multiplant concerns and least at branches of firms based elsewhere in the UK;

[10] These analyses took the form of multinomial logit regressions of (private sector) establishment responses taking as the dependent variable whether had (1) or had not (0) introduced new products or services in the past 3 years. The analysis was exploratory, involving a very wide range of potentially relevant independent variables drawn from among the 84 basic questions in the survey.

- ownership: innovation was substantially more likely in establishments owned by limited companies than in individually or partnership-owned businesses;
- occupational mix: innovation was more likely in establishments with a higher proportion of professional, managerial and (especially) sales staff;
- area: after controlling for other factors, spatial differences remain, with the pattern now one of significantly higher rates in the south west (in areas lying between the CBD and Heathrow airport) and lower in the centre and the east side of London;
- business age: older firms tend to be somewhat less innovative, though innovation is not strongly concentrated among recently established firms.

Similar analyses using the 1996 survey, which offers a quite different set of independent variables, highlight additional links between innovation and:

- company commitment to strong growth;
- strategically significant links with customers, suppliers and (through joint ventures) also with collaborators;
- having public sector organisations among purchasers of the product or service; and
- emphasising design, specification and presentation, rather than price, fast response or image/reputation as selling points.

The key results from the two surveys are summarised in Tables 4 and 5 which include only the variables with a significant influence on the distribution of establishments between leader, follower and non-innovator status (for products or processes) when other influences are controlled for.

The methods used by innovating firms to develop their new products and services fell into three natural groups:

1. external advice and observation, including observation of other firms, externally commissioned advice, work undertaken with partner firms, and design assistance from suppliers and/or major customers;
2. formal or informal design/creativity from within the establishment; and
3. formal or informal design/creativity from other company sites.

Not surprisingly, the number of methods in the first two categories used by businesses was related to the importance which they attached to innovation. In addition, the use of internal development procedures was positively related to the size of establishment, while the use of resources elsewhere in the company was naturally excluded for single plant sites, and most common for branches of foreign firms. In relation to the outcomes of innovation, in terms of whether establishments secured a competitive advantage or just kept up, the use of creative inputs from other company sites increased the likelihood of a leader position, while reliance on observations of other firms was more associated with a follower status. Making use of the more leader-oriented methods of innovation was associated with multi-plant enterprises (particularly foreign-owned firms), and also associated with being involved in joint ventures (irrespective of where the partners were located).

These logit analyses highlight two general features of innovative behaviour in London. One of these is the role of business scale and organisation, with clear

evidence that, even in a conurbation offering the highest level of external economies, the propensity to innovate (especially in a leader role) is positively associated with internal scale factors. Moreover, this pattern is not simply due to differences in sectoral mix or market-localisation between smaller and larger businesses. As such, it is rather contrary to the emphasis of much recent academic and policy writing about the geography of innovation, which focuses on the particular locational and network requirements of recently established, small enterprises, as a key source of dynamism for regional economies. The point may be that such firms face particular difficulties in successfully pursuing innovative strategies, which may perhaps be reduced in cities/regions where agglomeration economies and/or open networks allow more of the support facilities and uncertainties to be externalised. In that case, the bias of innovation toward larger businesses could well be stronger elsewhere, but the simple fact is that innovating enterprises in London do tend to be significantly larger than average.

A second related feature is that innovative behaviour in London seems to rather little to do with the strong local inter-business connections highlighted in the co-operative, social network versions of the milieu literature. Elsewhere, we have shown that, with the notable exception of City financial services requiring rapid access to shared market intelligence, only a small minority of London businesses perceive significant advantages in being located near to related activities, with even fewer perceiving networking opportunities as the source of any such advantage (Gordon and McCann, 2000). This turns out to be as true of innovating activities as of others, with no particular link to perceiving advantages from clustering, and no evident effects from having more local/regional markets, suppliers or partners. The only possible exception is in relation to joint ventures which are associated with a greater likelihood of product innovation in a leader role. This effect is just as strong when partners are distant as when they are close, but London firms do seem rather more likely (than numbers alone would warrant) to form joint ventures with other London or South East-based firms. An implication of this ‘distance deterrence’ effect is that businesses in the agglomeration may be rather more likely to form joint ventures, but the difference may not be great, given that two thirds of the joint ventures are still with firms based outside London. Overall, for innovators as noted previously for London firms in general (Gordon and McCann, 2000), businesses appear to derive benefit from a London location in the diffuse and flexible manner implied by models of pure agglomeration rather than through the more specific and stable links highlighted in the social network model.

7. Conclusions: Clustering and the Role of Innovative Milieux

As with our aggregate data, our micro-econometric results presented in section 6 provide broad support for Hypotheses 1 and 3, and tend to refute Hypotheses 2 and 4. In other words, in the case of London region, the geography of innovation appears not to be primarily associated with either the behaviour of small firms, or with particular ‘trust-based’ social networks. Rather, the geography of innovation appears to be rather more related to orthodox agglomeration externalities. Moreover, in general we would argue that there is no reason to suppose that innovation is systematically maximised in any particular type of industrial cluster. Where firms rely on formal or informal inter-firm information spillovers to facilitate innovation, the likelihood of

successful innovation by a single firm will generally be maximised within a spatial cluster. However, several distinct forms of spatial clustering involving either pure competition, stable inter-firm relations, or trust relations are all capable of facilitating the inter-firm flow of information., and it is a mistake to privilege the social network model as holding the key to such interactions. In other cases, where firms do not rely on informal information spillovers to facilitate innovation, spatial clustering may be either be irrelevant or even disadvantageous, where secrecy is a major concern (Simmie 1998a,b; Simmie and Hart 1999). A case in point is the pharmaceuticals industry (Simmie 1998a,b; Simmie and Hart 1999) whose innovation strategy involves experimental development of many drugs, each with a low probability of success, relying on large numbers of independent trials, rather than external economies of agglomeration to resolve uncertainty into acceptable levels of commercial risk. Also in this case it is significant that it is the scientific community (and regulatory bodies) which must verify success, supplanting the potential role of a local interpretative community. The result is that this type of highly innovative firm and industry has no particular requirement for spatial clustering, behaviour will be governed by traditional locational factors such as access to appropriate infrastructure, labour inputs and perhaps also to public decision-makers (as proxy for a market). Similar arguments apply to some other highly innovative industries including aerospace, defence industries and medical instruments, where co-location would be primarily a response to common location factors rather than social networking or more general information spillovers.

Even in the types of innovative sector highlighted in the literature on ‘new industrial areas’ (notably the US small-firm electronics industry) there is reason to believe that claims about the significance of the informal information spillovers enabled by spatial proximity are significantly overstated. A key reason is that realised product and process innovations which involve more than one firm depend on formal information flows as well as informal information spillovers (Audrestch and Stephan 1996, Audrestch and Feldman 1996, Suarez-Villa and Walrod 1997), and that the intensity of these formal information exchanges is relatively insensitive to geography (Arita and McCann 2000). The London region evidence in this paper also indicates that joint ventures and strategically important relations with key clients and suppliers can boost innovation even when the partners are distant. Despite an emphasis on the significance of clustering at an urban or sub-regional scale, sometimes backed up by rather anecdotal evidence (Larsen and Rogers 1984; Saxenian 1994; Castells and Hall 1994) empirical work suggests that information spillovers often operate over regional, inter-regional, and international spaces (Cantwell and Iammarino 2000). Even in the particular high technology industries highlighted in the literature, clustering at an urban scale may arise for reasons other than information spillovers or trust networks, often in relation to the agglomeration economies of transportation and common labour pools, and cannot in itself be taken as evidence of such milieux effects.

In both the broader ‘industrial clusters’ literature and that focused on ‘innovative milieux’, there is a tendency to conflate a series of distinct, and sometimes contradictory models of agglomerative processes, without distinguishing what evidence is relevant to which. At the general level this arises in relation to the respective roles of complexes, social networks and pure agglomeration in the success of clustered activities (Gordon and McCann, 2000). In the specific case of innovative activities we have identified four very different types of explanation – two variants

each of the product cycle and milieux themes – each potentially accounting for major spatial variations in innovative success, though with differential relevance to different types of activity. Within the milieux theme, these involve sharply contrasting emphases on the significance of competition versus collaboration in promoting concentrations of innovative success. In relation to policy initiatives aiming at boosting competitive advantage these have radically different implications both for appropriate methods and for the feasibility of seeking to develop sub-regional innovative clusters. The evidence presented here from studies in the UK's leading metropolitan region, both those of Simmie and colleagues, and the analyses here of the London employer surveys, suggests that in this case at least, the key elements both at local and regional level involve a combination of: sectoral location factors; comparative advantage; and an array of pure agglomeration economies, rather than more particularistic spatial networks. Elsewhere there may be areas and sectors in which the firm-organisation-industry structure-geography arrangement of the social network model is appropriate. But there is no reason to take this as the blueprint for future industry developments, or to assume that innovation is necessarily maximised by such an arrangement. Pure agglomeration, industrial complexes, and firm isolation may all produce comparable results.

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Table 1.
Industrial Clusters: A Transaction Costs Perspective

	pure agglomeration	**industrial complex**	**social network**
characteristics			
firm size	atomistic	some firms are large	variable
characteristics of relations	non-identifiable fragmented unstable	identifiable stable trading	trust loyalty joint lobbying joint ventures non-opportunistic
membership	open	closed	partially open
access to cluster	rental payments location necessary	internal investment location necessary	history experience location necessary but not sufficient
space outcomes	rent appreciation	no effect on rents	partial rental capitalisation
notion of space	urban	local but not urban	local but not urban
example of cluster	competitive urban economy	steel or chemicals production complex	new industrial areas
analytical approaches	models of pure agglomeration	location-production theory input-output analysis	social network theory (Granovetter)

Table 2
Product/Service Innovators in Greater London 1994-6

	% of establishments	%. of workers	Mean Size (employees)
Non-innovators	52.5	41.5	18.8
Innovators of which:	47.5	58.5	29.2
Followers	17.7	23.1	25.5
Leaders	19.6	33.5	33.3

Source: 1996 London Employer Survey.
Note: Followers comprise product innovators who perceive their position as still behind, or keeping pace with major competitors; leaders are those perceiving themselves to have a moderate or very powerful competitive advantage following their innovation.

Table 3
Product and Process Innovators in London by Life Cycle Stage

	Trend in Overall Market Size for Product Group				
	Rising Rapidly	**Rising Slowly**	**Stable**	**Declining Slowly**	**Declining Strongly**
Product Non-innovators	25%	40%	50%	53%	64%
Innovators of which:	75%	60%	50%	47%	36%
Followers	25%	24%	20%	23%	14%
Leaders	47%	32%	27%	20%	20%
Process Non-innovators	28%	42%	47%	55%	53%
Innovators of which:	63%	48%	47%	40%	42%
Followers	23%	19%	26%	22%	20%
Leaders	38%	27%	19%	18%	20%

Source : 1996 London Employer Survey.
Notes: 1. see Table 2
2. percentages relate to the estimated share of in each type of establishment.

Table 4
Logit Analyses of Innovation Probabilities from 1999 London Employer Survey.

	Product Innovation	
	Leader	**Follower**
Establishment type:		
Single plant	1.00	0.78
Headquarters	1.33	1.18
Branch of UK firm	0.89	0.79
Branch of foreign firm	1.00	1.00
Ownership		
Limited company	1.53***	1.33**
Employment (logged)	1.29***	1.17***
Establishment Age (logged)	0.92*	0.95
Sector		
Printing/publishing	1.53*	1.29
Construction	0.45***	0.34***
Information/comms technologies	2.94***	1.79**
Hotels	0.36**	0.59
Main market:		
In London or South East	0.66***	0.80*
Life cycle stage of product market:		
Rising strongly	2.55***	1.10
Rising slowly	2.24**	0.97
Fairly stable	1.15	0.81
Declining slowly	1.16	0.84
Declining strongly	1.00	1.00
Occupations' share of Workforce		
Professional, ???	1.35***	1.22*
Sales	2.72***	2.46**
Location		
South West London	1.61***	1.29*
Pseudo R-square (Nagelkerke)	0.159	
Chi Square (and df)	693.0 (36)	
Valid cases	4602	

Notes:

1. included categorical variables and covariates all selected on the basis of significance at 5% level;
2. significance levels for individual variables or categories * = 10%; ** = 1%; *** = 0.1%;
3. coefficients recorded for the categorical variables represent proportionate effects on the odds of innovating (as leader or follower); for the two logged variables they represent 1.0 plus the elasticity of these odds with respect to establishment age or employment numbers (respectively) ; for the occupational shares they represent the effect on the odds if all (rather than no) workers were in the occupational group concerned.
4. South West London here comprises the boroughs of Hounslow, Richmond, Kingston, Ealing, Merton, Wandsworth and Lambeth.

Table 5
Logit Analyses of Innovation Probabilities from 1996 London Employer Survey.

	Product Innovation		**Process Innovation**	
	Leader	**Follower**	**Leader**	**Follower**
Establishment type:				
Single plant	0.68	1.37	0.78	1.78*
Headquarters	0.91	1.50*	1.09	1.54*
Branch of UK firm	1.05	1.78*	1.25	1.54
Branch of foreign firm	1.00	1.00	1.00	1.00
Employment (logged)	1.11**	1.04	1.31***	1.24***
Sector				
Printing and publishing	2.26***	1.71*	2.34***	1.75*
Construction	0.66*	0.49**		
Information and communications technologies	4.74***	3.07***	3.23***	1.80***
Education	0.84	2.38*		
Main market:				
In London or South East	0.58***	0.57***		
Main source of competitive advantage:				
Price, speed or proximity	0.60***	0.79*	0.65**	0.89
Design or presentation	1.63*	1.78*		
Life cycle stage of product market:				
Rising strongly	3.58**	1.51	2.78*	1.84
Rising slowly	1.98	1.17	1.45	1.23
Fairly stable	1.44	0.88	1.19	1.22
Declining slowly	1.34	0.94	1.05	1.26
Declining strongly	1.00	1.00	1.00	1.00
Sales Objectives to:				
Grow strongly	4.94*	3.67*	6.36*	1.89
Grow gradually	2.84	2.40	4.51	1.36
Stay about same	1.26	1.35	1.10	0.62
Reduce or close	1.00	1.00	1.00	1.00
Links with:				
Suppliers	1.40**	1.29*		
Customers	1.47***	1.31*	1.58***	1.50***
Joint venture	1.42**	1.36*	1.37*	1.52***
Pseudo R-square (Nagelkerke)	0.215		0.192	
Chi Square (and df)	527.5 (42)		449.6 (32)	
Valid cases	2523		2489	

Notes: see Table 4 notes 1 to 3.