Evolutionary Economic Geography, Regional Systems of Innovation & High - Tech Clusters

FINAL VERSTION

Philip Cooke & Carla De Laurentis

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Introduction

Evolutionary economic geography integrates numerous strands of heterodox spatial fields. Some parts of even 'new neoclassical' theory, such as increasing returns, aspects of endogeneity in growth processes, and notions of abiding spatial disequilibrium as the resultant of increasing returns to spatial scale (Krugman, 1995) provide interesting insights into why some regions are rich and others poor, to echo Malthus' famous question of Ricardo (Landes, 1998). But this is all, for there are few other distinctive contributions to be made from that quarter. One sub field of regional science that is more squarely compatible with an evolutionary approach is that dealing with regional innovation systems (Braczyk et al, 1998). It is avowedly neo-Schumpeterian, translating that author's resolutely aspatial economist's mode of analysis and bringing further life to it. Indeed, elsewhere it has been argued that one reason why it continually attracts fascination is that regional innovation systems analysis gave a boost to more general innovation systems thinking. This, according to Carlsson (2007) is the dominant innovation studies field since refereed articles began appearing in the mid-1990s (Cooke, 1992).

The reason for this is explored in section 1 of the chapter, arguing that the conceptual perspective of industrial economics, often referred to as 'industrial dynamics' in the innovation studies literature is vertical – down the sector, as it were, from the vertically integrated large firm to its suppliers and support organizations. In the old days of the 'Industrial Age' when multinationals evolved as vertically integrated behemoths, pursuing industrial organisational processes that could be captured in simple 'S' shaped curves by the likes of Vernon (1966) this fitted a linear theory of innovation. But, as is well-known, that model began breaking down not long after it

was conceptualised, and large firms began to outsource even essential requirements, chiefly to respond to Japanese 'lean production', although the formulation of that academically came some twenty-plus years after Vernon (1966) in the 'lean production' bible of Jones et al. (1990). The geographical imagination is more horizontal, finding little difficulty even seeing much of what hitherto passed for vertical integration as far from complete. One only had to have spent time in 1950s-1960s Birmingham or Coventry, as this rurally-raised author did on frequent visits to relatives who had migrated from the declining Welsh coalfields to seek a better life, to experience the shock of seeing numerous (usually black-painted) brand-new truck chassis with unenclosed engine and wheels, and hung-on temporary license plates, being driven through the city-centre to one of many distant city coach-building specialists to be finished, to experience 'agglomeration' at first-hand (Boschma & Wenting, 2007) .

This chapter then moves into an analysis of regional evolution, especially regarding systemic innovation. Important concepts are juxtaposed involving the more interesting fringes of new neoclassical economics and a resolutely systems analytic approach to urban and regional studies, whose origins also lie in the 1960s, based in general systems theory, as in much natural science, engineering and technology, evolving from there as a complex analytical and guidance model expressed in the discourse of 'systems theories of planning' (McLoughlin, 1969; Chadwick, 1971). This was the integrated 'substance and process' approach to spatial analysis that modernised a professional urban design approach that had hardly changed since the Pre-Raphaelites, by virtue of modelling urban and regional systems mathematically, utilising gravity models, and the like, to predict behaviour. It was over-ambitious, complicit with what are now perceived as destructive biases in favour of, for example, subsurbanisation, separation of land-uses, primacy of vehicular mobility in cities and the destruction of traditional heritage and ambient city environments. However its underlying conceptual analysis, unlike its prognostications, was effective at facilitating representations of complex process realities in non-trivial ways.

Something the same can be said of the more mainstream innovation systems approach, which populates its perspective on the object of interest with core systems concepts such as 'networks, nodes and interactions' including feedback and

'institutional learning' (Lundvall & Johnson , 1994). Accordingly, as noted, it is open to small elements (increasing returns, asymmetric information, principal-agent relations, and possibly transaction costs) of new neoclassical economics or spatial econometrics. This is also due to *its* Neo-Schumpeterian interest in variety, search, selection, routines, trust, and embeddedness. But it goes further in sharing interest with both regional innovation systems and, for example, Italian industrial district theory, in collaboration, innovation, learning, path dependence, institutional change, disequilibrium and knowledge intermediation practices of institutions and organisations, including firms Boschma & Frenken (2005). These 'bring life back into economic(s) geography' to paraphrase Hodgson (1993). In what follows, the chapter reprises and updates the case for an evolutionary approach over any alternative approach to the understanding of spatial process. Finally, having made the connection to the evolutionary study of regional innovation, one strand of the broadening field of evolutionary economic geography, the chapter finishes by devoting empirical attention to search and selection procedures conducted by high-tech businesses in UK ICT agglomerations of which the M4 motorway corridor is one, and East Anglia, centred upon Cambridge, is the other main element. The interest here lies in the discovery of practices of possibly adverse search and selection. That is, what is normally presumed to be an asset of agglomerative behaviour – indeed it is said to be a main driver of the 'cluster craze' (Asheim et al, 2006) – namely access to prized 'knowledge spillovers and 'swift trust' (Sabel, 1995) turns out to be associated with quite high transaction costs and extortionate rents, the apotheosis, in other words, of diseconomies of agglomeration.

Theorising Evolutionary Economic Geography

Neoclassical theory hypothesises that economic actors are homogeneous, rational, non-opportunistic and capable of calculating best value optimal decisions in a world without uncertainty. The firm is the centrepiece of this ratiocination. Here, economic actors transform inputs into outputs represented mathematically as a production function given appropriate technology and, through the market, an external price mechanism for estimating costs and calculating optimal profit. Technology is exogeneous, but also endogenous for new neoclassicals, firms being assumed to have comparable technological competences (Romer, 1990). Firms' other important

characteristics are similar, remaining so during their life cycle. In a world without uncertainty, contracts can be complete and fully definable. For the neoclassicals, competition is pure and perfect, no barriers exist to market entry, and firms have equal access to resources, knowledge and information that are freely available, and optimal labour and capital input co-ordination is affordable.

In essence, the neoclassical model is one in which the firm's decisions and activities are driven by the price mechanism in a world of pure and perfect competition. Fundamental questions, which neoclassical theory provides no answer to, concern growth and development, co-ordination and knowledge. In the neoclassical tradition, firm growth is a sign of imperfect competition, one of the many paradoxes arising from a prejudice in favour of equilibrium as the natural economic state. Neoclassical theory also fails to explain mechanisms observed in the real world such as partnership, networkng, or oligopoly because it assumes the uncertainty which these practices denote is non-existent. Similarly, heterodox proposals regarding the normality of firm and individual choice as satisficing rather than optimal decision-making cannot satisfactorily be allowed without relaxing the absence of uncertainty principle, as the new neoclassicals in fact commonly do (Simon, 1962). Nor can the impact of phenomena such as history, routines, location of research and production centres or advantage of technological and individual skills superiority be modelled. Despite recognition that much technological advance is endogenous (Romer, 1990), the "new" neo-classical models are still "mechanical": uncertainty, conflicts among experts, unexpected results that mark the innovation process are not integrated (Nelson 1995). Moreover the endogenous outcome remains the technological artefact, and classical form of 'congealed capital' rather than the more embedded and embodied form of innovation.

As suggested in the introduction to this chapter, evolutionary economics has a different way of conceiving economic actors, firms and markets. It places a pronounced emphasis on history, routines, and interactions and influences of environment and institutions. Firms are conceived of as specific actors, or preferably, agents (Pavitt 1986). Moreover, following Simon's (1972) observation of the impossibility of any single agent having omniscience with regard to information appropriate to optimal decision-making, given the complexity of their environment

and conflicts of interest that disallow profit maximisation, agents are not assumed to be able to compute optimal solutions and even less to predict other agents' behaviours because of uncertainty (Heiner 1983; Knight 1921; Alchian 1950) Hence, bounded rationality (Simon 1962; 1972), satisficing behaviour and differing expectations (Hahn 1952, Rosenberg 1982) are taken to be normally expected practice. In evolutionary economics, firms are not uniform but distinctive, and utilise differentiated capabilities, one of which is knowledge, another is administration and management. As Penrose (1995) saw, both knowledge and organisation play significant roles. Increasingly, even compared with the era of Penrose (1959), knowledge and externalised knowledge networks were seen to have risen in importance due to the increase of *innovation* as a factor of the firm's self-constructed competitive advantage. While the organisation of a firm as an efficient and effective form of administration, managed to optimise this and its other resource capabilities had never been a stronger factor in its development, aided increasingly by institutional and organisational learning. From an evolutionary perspective, firms learn from their own experience but also from other firms and organizations they interact with and with whom they exchange knowledge both organizational and technological. Evolutionists recognise firms have histories, path dependencies and development trajectories. They may show capabilities of survival and prosperity in maintaining a relatively unchanging market location, as is the experience of many banks, for example, or they may have a special capability of transforming themselves to fit new market locations by virtue of their foresight competence, like Dupont or Nokia, as cases in point. The latter explore new paths of growth to exploit; the former adapt more to new demands by incorporating learned routines, outsource technological requirements, learn of new opportunities, and adapt to new constraints. If not, they succumb to competition and become an acquisition, possibly of some mew, more innovative vehicle (e.g. private equity business) and if they cannot evolve to meet new market exigencies they exit the market.

As this chapter focuses empirically upon some evolutionary learning characteristics of clusters, it is worthwhile postulating some possibly original dimensions differentiating a more neo-classical from an evolutionary line of reasoning and hypothesising between the two. Here we refer to the different perspectives upon the role of knowledge spillovers in the emergence of clusters. Keep in mind clusters are more

than agglomerations of sectoral neighbours in geographic proximity. Connectivity through communication, trust, reputation, favour-exchange and other forms of collaboration are involved, as shown in the empirical section of this chapter. Knowledge spillovers are part of the adhesive in these arenas of high social capital but also competition. The neoclassical approach to knowledge spillovers and clusters as drivers of growth is represented in the Marshall-Arrow-Romer position that privileges *specialisation* of knowledge and expertise as the growth driver. Hence the fewer inter-sectoral knowledge spillovers that reduce the effectiveness of absorptive capacity the better. Single clusters in a possibly random darts in dartboard-like space would be consistent here.

An evolutionary approach would be more akin to Jacobs (1969) and her well-known proposition that diversity is the dynamic driving innovation (see Chapter 23 in this book). From a cluster perspective, this leads to a hypothesis about cluster mutation as an emergent property of 'Jacobian Clusters'. The evolutionary terminology here would be that of related variety and proximity effects hastening lateral absorptive capacity among mature and embryonic clusters. Precisely this phenomenon is found in places like California, North Jutland, Wales (Cooke, 2008a & b) and as Boschma (2005) shows Emilia-Romagna. In the former cases convergence then cluster emergence shows specific path dependence (see Chapter 3 in this book) from ICT through Biotechnology to Clean Technology clusters in California and agricultural and marine engineering through wind turbines and solar thermal energy clusters in North Jutland and Wireless Telephony through Medical Technology to Biotechnology. Predecessor clusters emerged after Schumpeter's fifth innovation category of 'railroadization' had opened up the respective territories in the 1800s. In Wales agro-food stimulates emergence of renewable energy cluster emergence (bioethanol and biomass) while electronics, automotives and aerospace share common spaces, skills and competences. Cluster related variety based on engineering skills typifies 'Third Italy' clustering according to Boschma (2005). Clearly this is a powerful explanation for regional evolution and associated policy thinking.

Evolutionary Theory and Regional Evolution

Having introduced the distinctiveness of Jacobian clusters, this section takes that insight as a basis for examining first the regional, then the local cluster forms of

regional evolution. As indicated, evidence has been accumulated to show that regions can improve their prosperity by adjusting or even transitioning in relation to their historic path dependence and history. This is by no means easy, but possibly due to the over-ambitious prospectus of 1960s systems planning and reflection upon the need to prioritise system 'levers', experiment by moving away from uniform policy prescriptions and evolving an integrated substance-process approach to regional development, with constant monitoring and adaptation, regions can become innovative systems. They may previously have been non-innovative systems, 'locked-in' to an apparently evaporating industrial paradigm, or they may have been fragmented industrial regions possessed of diverse and unconnected economic elements, and for these the evolutionary challenge to search and select a survival strategy on which to build a success strategy is at its most acute. The temporal dimension, in the absence of accomplished governance of this process may be long enough to be economically fatal and the region never develops, but it may be foreshortened by judicious application of the knowledge and organisational competences Penrose (1995) sees as characteristic or the organisationally and cognitively sophisticated firm.

In evolutionary theory, it will be recalled, firms are conceived of as collective organizations with a variable degree of internally-generated and externally learned resource-development capability. Regions and regional development have more in common with this perspective than with the neoclassical world of homogeneous, atomistic units of rational utility maximisation. Accordingly, the evolutionary theory of the firm and the region enjoy greater conceptual complementarity. Conceiving them as differentiated, making use of variable proportions knowledge and capability inputs and benefiting from methodologies both for learning and, more importantly knowledge-generation, upon which economic advantage may be constructed are key in this. Such capabilities are path-dependent (Arthur, 1994) but not predetermined, they can be learned, thus widening the range of feasible innovation opportunities affecting economic progress. Path dependence is criticised as inclining towards the deterministic, but it can be shown to make a significant contribution to understanding cluster evolution through related variety in 'Jacobian clusters' (above Section 2 and below Concluding Remarks). Related variety can be seen as rather static and even conservative in its reliance on official statistics but it can be dynamised in cluster

theory by the evolutionary notion of 'cluster mutation' (*ibid.*). Networks are shown from the research reported in the penultimate section of this chapter to be the defining feature of clusters defined as geographically proximate social capital for purposes of firm evolution. More generally, such relations are also globalised through 'distant networks' which, among other things, help explain 'open innovation' i.e. global outsourcing, even of research if not yet of innovation where spatial proximity still seems vital.

Unlike the neoclassical world of isolated utility-maximisers for whom technology and learning gains are still largely exogenous, purchased off the shelf, the evolutionary world is one in which innovative, imitative, unpredictable and Pasteur's 'fortune favours the prepared mind' effects occur. Illustratively, but empirically true, a region that might be deemed, in effect, redundant since its population had largely left to seek opportunity elsewhere, its agriculture was uncompetitive and there were in any case low linkages with existing manufacturing industry, itself non-innovative, might turn around even in these least auspicious conditions. In a world of 'peak oil' and energy insecurity, the empty fields of the dying agricultural economy might be reinvigorated by the judicious interactive innovation of selecting them to be suppliers of bioenergy to the manufacturers who hitherto were un-innovative and thought they had nothing to discuss with the representatives of the remaining farmers. Regions like the American mid-west, former East Germany not to mention central-southern Brazil are experiencing such an evolutionary regional development process because what was once a marginal and far-fetched, systemic idea – a post-fossil fuel economy – has moved closer to the mainstream.

These changes have the consequence that, through interaction with other firms and agencies, the economic environment is itself modified as well as exerting its own modifying effects. The diffusion of both codified and tacit knowledge among firms in relatively equal relationship to one another, especially where they are competitive outside their domestic base but complementary, or even collaborative within it, is an important source of constructed advantage for small firms. But constructed it has to be; for example, while the aforementioned linking of traditional agro-food production with the world of large-scale energy production requires construction of new interactive networks. An interesting question is how precisely this happens. How, in

other words may related industrial variety arise from unrelated. Yesterday, farmers and automotive workers may have had little reason to interact closely except through the anonymity of the market where food and tractors were purchased. But today, in areas that were recently thought unviable in agro-food terms, the region of Mecklemberg-Pomerania in Germany, parts of northern England, and elsewhere, interactions among representative associations and research institutes from agriculture, energy and automotives have begun discussions and announced investments in biofuels (Jürgens et al., 2007; Goodall, 2007). The evolution of 'related variety' is why, for example, Italian industrial districts have proven capable of maintaining a competititve edge in traditional sectors despite competition from low wage, less developed economies. They have *systemic* process elements and knowledge flows inherent within and between them. In periods of relative economic stability, the system generates and absorbs externalities of the kind neoclassical theory assumes to be efficiently internalised in the institution of the firm (Boschma, 2005).

Such relationships are not *hierarchical*, they are *heterarchical*. Heterarchy is the condition in which network relationships pertain based on; trust, reputation, custom, reciprocity, reliability, openness to learning and an inclusive and empowering rather than an exclusive and disempowering disposition (Cooke, 2002). However, heterarchy does not operate in a vacuum. Modern regional development theory, even more than evolutionary economic theory stresses the importance of the socio-cultural *milieu* (Maillat, 1991) within which network forms of inter-firm organization are embedded (Granovetter, 1985). We are not here talking about community in a simplistic and generic way, rather about routine practices and mentalities of entrepreneurship in the context of a commercial community. As Marshall (1919) put it:

> ".... good work is rightly appreciated, inventions and improvements in machinery, in processes and the general organisation of the businesses have their merits promptly discussed; if one person starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas" (Marshall, 1919).

Theorisation of system weaknesses in heterarchic, localised forms of economic coordination has gone furthest in industrial district theory. Two key system weaknesses have recently been identified in the canonical neo-Marshallian form of the industrial district. Writing from an evolutionary economics perspective, Varaldo

and Ferrucci (1996) have identified the following developmental blockages presently visible in the district form of development. First, because of strategic co-operation between firms in districts there develops, of necessity, a common set of strategic expectations about behaviour amongst mutually dependent entrepreneurs. Institutional memory, rules, routines, ways in which mutual expectations are regulated, relationships ordered and rules governed, come to converge so that dissonance within the district becomes muted. This, the absence of dissenting voices, reproduces district culture - in the commercial sense - but may delay *strategic* creativity at critical points when a rapid response to the need for innovation is required. If we remember that innovation is defined as the *commercialisation* of original knowledge, as distinct from invention, which is the original knowledge itself, then the need for rapid response becomes obvious.

Second, this is not a problem until the district system experiences an exogenous shock, such as a stabilisation, or even, as occurred in the global recession of the early 1990s, a contraction in demand. This can cause a number of panic responses: competition may become cut-throat and destructive; low prices make investment in restructuring impossible; reduced demand limits the high flexibility levels associated with district firms, revealing hidden costs as margins are cut and more standardised production is resorted to; firms seek cheaper offshore suppliers and even production locations; retail customers are more able to negotiate favourable contracts for themselves; new technologies may represent a threat where they are incongruent with the technical know-how of district entrepreneurs. All these reactions can be experienced in non-district settings too, and there is even limited evidence that in Italy, during the 1990s recession, district firms fared better than similar ones outside districts (Brusco et al., 1996).

However, these forms of industrial organisation have proven remarkably resilient, adapting skills and technologies and responding to inauspicious external conditions. Most recently, in the mid-2000s some are thriving by absorbing large numbers of Chinese workers and entrepreneurs, at least 30,000 in Prato, one of the most traditional textile towns in Italy (Dei Ottati, forthcoming). Founded in its modern form as an initially impoverished local economy based on the recycling of wool, in effect from rags, to be re-woven into fabric by multitudes of small artisans, the district

has dealt with external acquisitions of some key firms, the innovation imperatives of new software-controlled machines, and much competition from low-wage economies in core markets. The arrival of many Chinese entrepreneurs has brought new skills and upgrading of the commodities on offer, including designer clothing and accessories. There is some irony in that a major migration flow is from China's clothing and textiles 'industrial villages' in southern China to which the Italian Communist Party, which then ruled in Tuscany (and Emilia-Romagna), often sent consultant advisers on how to build industrial districts in the People's Republic (Becattini, 2001).

The Systemic Dimension of Innovation

Most economic development involving enterprise support for small and medium enterprises occurs in situations far removed from the industrial district model of development. Varaldo and Ferruci (1996) concluded that the future of Italian district firms relied more and more on their capacity to make links to non-district firms displaying strategic competitive advantage, including crucially, networks of global firms. Instead of tightly-defined districts, their model for the future was of more loosely-defined "clusters" of inter-firm relationships. These were thought capable of taking advantage of the incremental innovation made possible in periods of relative stability where close networks and what we now call 'related variety' could facilitate rapid information diffusion and learning. But for the more dynamic, strategic innovations by means of which global competitiveness is sustained, firms in local networks need to be in touch, not necessarily directly, but through the supply-chain, with global networks. Clearly no-one saw the likelihood of globalisation producing an involuted evolution of certain districts (especially clothing and textiles-related) with Asian immigrant upgrading to the fore. Nor at that time was the establishment of new districts in low-wage countries like Romania envisaged. Finally, as Becattini & Coltorti (2006) make clear, the performance of Italy's industrial districts in the post-war epoch has generally out-performed the rest of the economy in terms of firm and employment growth.

If we broaden the discussion of economic development from the local to the regional level, keeping the possibility of an exploration of the systemic relationships open, then we are drawn into reflection on the notion of "cluster" since it is the systemic

rather than simply agglomerative nature of the phenomenon that is of potential interest and the cluster concept rests on that characteristic. We may briefly explore two related but distinctive elaborations of the basic cluster idea and, in the process, say more about the *systems of innovation* approach to thinking about how these may be co-ordinated. The *systems* dimension arises from the "membership" of the network comprising the cluster. Minimally, the *innovative region,* especially of the high technology kind, may be expected to have agglomerations of new technology businesses that have the characteristics, denoted above, of clusters. It is crucial not to see 'cluster' and 'regional innovation system' as synonymous. This is for three reasons: in scale terms clusters are seldom regional but local; clusters have very different governance mechanisms from regions, ranging from associative 'clubs' to little more than regular market interactions; and regions may contain many clusters (or none) as well as other organisational forms of industry. Clusters too vary, and not only in terms of governance. In Bottazzi et al. (2002) and Paniccia (2006) useful, but very firm-focused typologies range from 'horizontally diversified' through 'Smithian' supply chain to 'oligopolistic' and 'science-driven.' Conceivably, examples of each might be found in a region. The key point about the concept of *cluster* is that while it will consist of firms, large and small, in a lead industry and supporting activities, it is the interactive nature of such firms, ranging from doing business to doing favours, that is its generally distinctive feature.

Further network relationships may exist proximately or virtually, with research and higher education institutions, private R&D laboratories, technology transfer agencies, chambers of commerce, business associations, vocational training organizations, relevant government agencies and appropriate government departments. This constitutes the basis for an integrative governance arrangement. The club, forum, working party, consortium or partnership model is what typifies this *associative* (Hirst, 1994; Casson, 1995; Cooke & Morgan, 1998) approach towards enhancing the commercial community. From such arrangements institutional learning and innovation gains may more readily be acquired. So the second dimension, foreshadowed above, is the *associative governance* of the cluster. Conceptually, this involves a major shift from state-regulation of economic affairs to a degree of self-regulation by responsible groups in economy and society, but not strictly 'liberal market' governance. In Hirst's (1994) formulation this means ceding some aspects of

economic governance to associations at large capable of managing certain aspects of communal provision (such as vocational training or technology-transfer), supported by appropriate financial mechanisms. It also implies decentralised, transparent and consultative governance. Institutional learning is a crucial part of an associative approach. It presumes no fount and origin of all wisdom, rather it assumes the processes of economic development and especially innovation are interactive ones in which institutions on the user-side (e.g. customers) may be as important as producers (e.g. scientists) of the innovations in question. Localised cluster evolution can be significantly assisted by associative institutions and organisations such as these. They in turn may occasionally act collectively where a regional agency has capabilities to supply further, more strategic, support. In the next section the chapter moves into a report of research findings into he question of whether firms in clusters perform better than their ICT sectoral equivalents if they exist in clusters and collaborate on research and innovation activities.

Measuring the Effect of Proximity and Collaboration on Firm Performance

The research to be reported upon here administered postal questionnaires to structured samples of UK healthcare biotechnology (not covered in this chapter; for methodological detail of the project, see Cooke et al., 2007) and ICT companies (264 hardware, software and services respondents) inquiring about comparative firm performance of collaborator and non-collaborator firms in and outside clusters. Clusters were defined as being located among sectoral neighbours and actively collaborating with them in a general, possibly informal way or co-operating specifically and contractually on some topic such as R&D, knowledge transfer or marketing, as well as networking distantly in the same respects. Non-collaborators defined themselves by reporting they did no such partnering, formal or informal with firms or organisations inside or outside the cluster. They claimed they only engaged in market exchanges with customers or suppliers. This addresses a matter of key practical importance to this contribution, namely whether firm performance is affected by business ‘clustering’.

Given what has already been written above regarding the *specialisation* emphasis in the work of neo-classicals and that perspective's neglect of non-market exchange interactions, it would be unlikely to hypothesise collaboration though it might hypothesise contractual co-operation. The richer evolutionary approach hypothesises both, and as it turns out, most fruitfully (on related issues, see Boschma & Frenken, 2006 for further discussion). In fact, from the evolutionary economic geography perspective, the really pressing question is whether it has a better explanation for clustering than the neoclassical approach, and if so why. To tackle this, the data first report more general interactive characteristics of firms in clusters. It is important to establish the extent to which firms consider themselves 'collaborative' whether in geographical proximity or not. In particular it is interesting and important to separate collaborator performance from general performance and key indicator data for ICT are presented in Table 1, which compares key performance indicators for firms that collaborate, do not collaborate and their cluster/non-cluster location. Analysis was undertaken with respect to measures of firm performance, namely employment change, turnover change, research and development expenditure change, and innovation, all between 2000 and 2003. In this respect, levels of innovation were measured by asking firms about the number of new products/service and changes to products/ services in the past three years from survey time, the number of patents announced, R&D activities and the firm's capacity to introduce new products/services compared to competitors.

Table 1 shows that in all economic performance, collaborating UK ICT firms' mean performance is generally better than the mean scores in the respondent group as a whole, consisting of both collaborators and non-collaborators. Thus collaborators have superior performance regarding market share, capacity to introduce new products and services, higher R&D as a share of turnover in 2003, more employees per firm and greater turnover, showing a higher share of firms that recorded an increase in both figures between 2000 and 2003. Thus collaboration clearly pays in most dimensions of measurable firm performance. Hence we continue to believe on the basis of our evidence that collaboration provides a competitive advantage. Of course, high performance may attract collaboration, which would be an excellent evolutionary inference. Accordingly, it is not unreasonable to propose that ICT firms

engaging in collaborative activity with others are more capable on the R&D and patenting input side of the innovation relation and they benefit on the output side with greater market share. This is also confirmed in Table 2 which shows how collaboration is significantly and positively associated with key performance and innovation indicators.

A further key question is the extent ICT collaborators – not forgetting non-collaborators – are found consciously locating in clusters. The answer provided below shows a picture where geographical (cluster) proximity for UK ICT firms is important, as shown by the number of non-collaborating firms that consciously decide to co-locate in a cluster (56%), but whether this is proven to be beneficial for firms' performance is somewhat unclear. The operation of knowledge spillovers seems to be important, where substantial numbers of non-collaborators are found in clusters indicating that there is a 'knowledge spillovers' attraction effect even for those who

Selected Performance Indicators	**All respondents**	**Collaborators**	**Non-Collaborators**	**Collaborators**		**Non-Collaborators**	
				Cluster	**Non-Cluster**	**Cluster**	**Non-Cluster**
Mean Employment	105	180	40	57	53	19	41
Employment Increase 2000-3	36%	40%	34%	45%	41%	39%	39%
New Products/ Services 2000-3	80%	88%	73%	89%	87%	74%	69%
Patents 2000-3 +/-	0%	2%	-2%	6%	4%	-3%	0%
Turnover Increase 2000-3	61%	69%	55%	70%	76%	49%	70%
Mean R&D Expenditure/ Turnover	16%	17%	14%	19%	13%	10%	11%
R&D Expenditure Increase 2000-3	31%	32%	30%	39%	16%	22%	33%

Source: CASS ICT Collective Learning Survey

Table 1: Collaboration and Performance of UK ICT Firms

Note: 1) Respondents to the questions on collaboration/non-collaboration were fewer and had a smaller mean than all collaborators. Columns 5-8 have N=55, 40, 71 and 44 respectively.2) The few large multi-plant firms in the sample frequently reported collaboration with affiliates or sister plants, which clearly fell outside the project's defined interest in inter-organisational and inter-firm collaboration and co-operation. Hence they are excluded from Table 1.

envisage non-collaborative relations with their neighbouring firms. These may be assumed to be those seeking to exploit knowledge that is 'in the air'. Interestingly, collaborators in clusters perform only marginally better, but consistently so, than those not in clusters, except on R&D expenditure increase 2000-2003 where collaborators increased most. This could be a temporary peak, or it could mean they experience a cluster-effect for R&D expenditure if R&D expenditure increase levels remain high over time. Yet a further interpretation is that they are inefficient spenders of R&D investment that is only associated with marginally better overall performance than is the case for non-collaborators.

Focusing on the collaborators side, the table shows that for some indicators of economic performance collaborators in clusters perform better than collaborators in non-clusters. Collaborators in clusters tend to have superior performance regarding higher R&D as a share of turnover in 2003 (19 % compared to just 13 %), a higher number of firms recording an increase in R&D expenditure between 2000 and 2003, more firms announcing patents and number of patents announced in both 2000 and 2003. Clustered collaborators tend to be bigger than non-clustered collaborators and have a higher number of firms that increased their employment size between 2000 and 2003. However, while mean turnover of the two sub-groups is similar (£5 million in 2003), 76 % of non-clustered collaborators increased their turnover between 2000 and 2003. It can be concluded that collaborators in clusters tend to be superior on the R&D and patenting input side. However, in regard to the output side the higher investments in inputs do not benefit firm performance.

Turning attention to the non-collaborators, it is perhaps surprising that a significant number of non-collaborators consciously locate in clusters. However, the data reveal that non-collaborators in clusters perform better than their counterparts in non-clusters in just some innovation indicators (employment increase and new products/services). Contrariwise, non-collaborators in non-clusters spend more on R&D, have a higher proportion of firms that increased their R&D expenditure and turnover growth between the 2000-2003 period. It can be argued that clustering can provide competitive advantage to non-collaborators as the non-collaborators that co-locate in

geographical proximity are smaller in size (19 average employees compared to 41 for non-clustered firms and £2 million average turnover compare to £5 million for the isolated non-collaborators). This resembles a confirmation that economic spillovers are available as even neo-classical literature predicts in cluster settings. However it must be questioned whether notions like 'collaborators' and non-collaborators' would enter their econometric radars Nevertheless it would be consistent with their 'knowledge spillovers' attraction effect since small firms would be more rational in utility-maximisation terms to seek out such spillovers than more self-contained larger ones. In this respect, diseconomies of scale effects might be discounted. However, as shown in Table 1 and, later, Table 2, this may help innovation but it is not necessary benefiting firms' performance.

	Collaboration Effect on Performance	Respondent perception of collaboration	Perceived Innovation Effect
Capacity to introduce new products/ services	.059	.213**	.024
Market share improvement	.273**	.181	.112
Patent Announcements	.158*	.100	.075
Turnover increase	.172*	.236*	.199*
Employment change	.013	.182*	.145
R&D change	.038	.107	.086
Improvements of companies best products	.102	-.096	.323**
New products for company but not new for market	.029	.117	.142
New products new for company and new for market	.230**	.152*	.203**
Number of new products/ services	.102	.011	.157*
Number of changes in products/services	.081	-.003	.096

**Correlation is significant at the .01 level (2-tailed); *Correlation is significant at the .05 level (2-tailed)
Source: CASS ICT Collective Learning Survey

Table 2: Collaboration and Performance of UK ICT Firms

Table 2 presents correlations measuring associations between performance variables and collaboration effects and perceptions. Thus, in a novel way we compare expected outcomes of collaboration with realised firm performance on these variables. This helps us get at motivations for collaboration. The results show the following: first, collaborators display relatively high and statistically significantly improved market share, wholly new product or service (to firm and, crucially, market) innovation, and to a lesser extent, turnover and patenting improvements (consistent with Table 1). Interestingly, performance indicator expectations from collaboration coincided somewhat with the actuality, measured on the variable 'capacity to introduce new products or services' but actual performance on that variable was lower and not

statistically significant. This may be interpreted as a kind of 'over-optimism' variable where reality produced less from collaboration than expected even though there were respectable improvements in wholly new product innovation. A similar conclusion can be made regarding turnover increase. It occurred but not as much as expected. Conversely wholly novel innovation occurred more than expected, as did market share and patenting improvements but not employment. On innovation specifically, perceived and actual performance were marginally out of line, with wholly novel innovations being realised more in fact than expected to be the case by firms.

Proximity Indicator	All respondents %	Collaborators in cluster	Non-Collaborators in cluster
Swifter, Clearer Knowledge Exchange	79%	83%	72%
Reduce Interaction Cost	70%	66%	75%
Facilitates Informal Communication	87%	89%	83%
Reduce Uncertainty	59%	68%	36%
Facilitating Collective Learning	48%	55%	36%
Innovation Co-operation in Cluster	23%	26%	20%

Source: CASS ICT Collective Learning Survey

Table 3: Proximity, Cognitive and Innovation Advantages for UK ICT Firms

Table 3 concerns the value of proximity and answers questions regarding 'all respondent' and 'collaborator-non-collaborator' 'cluster-non-cluster' performance. The first five rows are firm responses as to what their respondent (CEO or R&D/Innovation manager) experience, beneficial or not, from cluster-based collaboration. It compares collaborators and non-collaborators in clusters on the same indicators. Row six reports, as the acid test, how much innovation co-operation, defined as contract-based and legally binding partnering, actually occurred. Collaborators favour spatial proximity to a greater extent than the respondent group as a whole and that of non-collaborators. Respondents answering these questions were low in number, with even those stressing clustering co-operation for innovation a minority compared to those conducting such activities with intra-firm co-operation (larger firms), and intra- or even extra-UK innovation co-operation. Spatial proximity is thought beneficial by clustered firms that collaborate as it facilitates informal

communication (89 %), facilitates knowledge exchange (83%), and reduces uncertainty (68 %) and interaction costs (66 %).

Interestingly, the reasons that motivate proximate location differ among collaborators and non collaborators in clusters. Most non-collaborating firms preferred clustering to reduce interaction costs, including transaction costs, whereas most collaborators valued this less. Non-collaborators also disdain reducing uncertainty and facilitation of collective learning more than collaborators. But on speeding up the knowledge exchange process and facilitating informal communication there is little difference between the two groups as shown in Table 3. The main anomaly requiring explanation here refers to the possibly strong neoclassical interpretation above that Table 1 indicates non-collaborators enter clusters to access knowledge spillovers. To begin with Table 3 shows some strong support for swifter knowledge exchange but also shows relative disdain, as noted, for the core neoclassical presumption of such entry 'reducing uncertainty'. Finally, it is noteworthy, if unsurprising, that despite all the enthusiasm and practical action taken by collaborators and non-collaborators to access communicative connectivity in a cluster, far fewer actually get into contractual innovation co-operations.

Puzzlingly, 20% of avowed non-collaborators also engage in contractual co-operations. From interviews conducted subsequent to the analysis of results with a representative sub-sample of the respondent population, two explanations arise. First, they perceive arm's length contractual relations as 'co-operation' and second, they actually do get into contractual innovation and other co-operations as defined in this research to some extent, since they are truly 'opportunistic'. Cognitively dissonant or rationally utility-maximizing? Perhaps firm-species mutation through learning to search and select for opportunity from the cluster ecosystem would be the most plausible. But it also has to be entertained that as active non-collaborators they find themselves more excluded than they expected given their main expressed knowledge spillovers interest in recruiting talent or contractual opportunities. Alternatively what is clearly 'in the air' in the cluster is information about patenting and R&D which is not of as much interest to them or is beyond their absorptive capacity. Probably a

combination of both lies close to the heart of the explanation, perhaps a ‘diseconomies of scale’ firm-cluster problem for non-collaborators is being experienced compared to the reverse for collaborators (also Table 1)

Hence we find convincing evidence from these results relative to the following three key dimensions. First, firms that collaborate perform better on nearly all performance indicators than firms that do not. Collaboration thus gives to firms in these industries an added competitive advantage. Second, collaborative firms in clusters perform better than collaborators not in clusters. Thus collaboration is good for business but geographical proximity is best. This means the cluster begins to take on the characteristics of what we wish to call ‘constructed advantage’. This is a dynamically derived form of advantage constructed upon the static qualities of agglomeration, which is transformed into a cluster by interactivity. Given these firms are in an ICT platform consisting of computing and communication hardware, software and services businesses they derive evolutionary ‘energy’ from *related variety.* Finally, the cluster offers an unexpectedly large portion of even non-collaborating (56 %) ICT firms constructed advantage. This arises from their conscious aspiration to access knowledge spillovers from the interaction effects and knowledge ‘free-riding’ opportunities available to firms within earshot of other incumbents with whom they have no intention of collaborating. The possibility that recruitment of talent is an element of knowledge spillover advantages being sought by such firms must also be taken into account. However, Table 3 shows they are frequently disappointed and some evolve to fit the cluster ecosystem by becoming collaborators against their avowed intent. Recall the significantly smaller employment size of these firms, which suggests that though this may not have been their primary interest, needs must.. In general, the constructed advantage of the knowledgeable cluster thus derives from its local linkages and conveys degrees of competitive advantage directly and indirectly to its collaborators and non-collaborators alike. This is underlined by data showing non-collaborators in clusters are small but perform better than non-collaborators of any size outside clusters.

Contrasts in Stylised Interpretations of Non-Collaborator Clustering: Neoclassical and Evolutionary

We have identified a somewhat unexpected practice by a significant portion of small and medium-sized enterprises in UK ICT. This is that there is sufficient attractiveness to locate in the midst of what are known to be clusters containing specialised and related variety firms with whom inward locators do not seek to collaborate in any intentional way. For the privilege, they are probably paying up to three times the land and labour rents they would pay in a not-too-distant science park environment outside the main clusters (e.g. M4 Corridor, Cambridge or Oxford). They are mostly small, even micro-firms rather than even medium-sized ones. Their only expressed reasons for this locational practice is possibly to hear of sub-contracts or of skilled labour availability. To repeat is not to 'piggy-back' a possible consortium engaged in innovative actions, of which there are numerous ones in such settings, such as *Symbian* for 'Bluetooth' and 3.5/4.0 generation mobile telephony in Cambridge (Cooke & Huggins, 2003). Rather they are superficially 'free-riders' hoping to benefit from moderate 'knowledge spillovers' for which they are willing to pay up to a 300% locational premium in conditions of great uncertainty. The uncertainty comes from the strong likelihood that to receive such spillovers they would have to have some knowledge with which to trade, which on the face of it seems unlikely, or worse, that they might expect knowledge in a cluster to be 'free-flowing' when in reality it may be more likely to be preserved in the 'club' atmosphere of locations such as Cambridge, where some such incumbents (e.g. in computer games) were socially excluded from networks involving the rather exclusive Cambridge Network Ltd, a firm established in 1986 on the San Diego CONNECT model to enhance network-based knowledge-flow among incumbent members (Cooke & Huggins, 2003).

We may stylise neoclassical and evolutionary interpretations of such, by no means exceptional firm-practice, according to criteria listed in Table 4. First, in regard to motivation, second in regard to uncertainty, third relating to utility, fourth information (resources), fifth expectations (e.g. of cluster), sixth price and finally, verdict as to whether such practice might be deemed economically rational or irrational. For example, the practices of non-collaborators getting low information (Table 3)

compared to their expectations, as well as not placing a particularly high value on 'reducing uncertainty. Some neoclassicals might

Criterion	Neoclassical	Evolutionary
Motivation	Externalities	Knowledge Spillovers
Uncertainty	High	Learning
Utility	Profit Optimisation	Knowledge Search
Information	Low	Selective
Expectations	Specialisation	Variety
Location Price	Very High	Spillover Cost
Rationality	Irrational	Rational

Table 4: Stylised Neoclassical and Interpretation of Non-Collaborative Clustering

see this as irrational, possibly as ‘adverse selection’ and inconsistent with neoclassical rational utility maximising or optimising norms.

Concluding Remarks

This chapter has proposed empirical evidence that gives confidence in the following key observations. First, and in theoretical terms, an advance in our understanding of the persistence and conceivable reinforcement of an asymmetric economic geography of prosperity and accomplishment. In an evolving and intensifying knowledge economy, science-driven and otherwise technologically sophisticated economic activity gives rise to demands upon industry organisation that reinforce collaborative activity among smaller knowledge-intensive businesses, on the one hand, and between smaller, smart firms and university laboratories towards customer (and supplier) firms, many of which can, on the other hand, be shown to be large or even

transnational corporations. This is important and original support for the thesis that *regional knowledge capabilities* increasingly determine the distribution of growth regions, currently favouring those that gain increasing returns from asymmetric knowledge distribution that assists in the construction of regional advantage in terms of talent recruitment and retention, spatial knowledge quasi-monopolies, and 'R&D outsourcing' or 'open innovation.' In UK ICT and biotechnology such features are pronounced with key bioregional capabilities attracting these advantages to clusters like Cambridge and Oxford, while for ICT, London and its satellites in the M25 and M4 corridors is the dominant market-led magnet.

We also found the evolutionary perspective far superior in explanatory power in apparently non-utilitarian circumstances that nevertheless make sense when analysed from the evolutionary point of view. This is promising from a policy as well as amore academic viewpoint since it seems policy-making from a neoclassical point of view produces often counter-intuitive interpretations. This is, of course, because of the poverty of neoclassical perspectives both upon knowledge and innovation analyses. This is perhaps surprising given that numerous founding fathers of neoclassical economics have stressed the importance of both, but owing to the unnatural restrictiveness of modelling in that field neither has seriously been explored by its adherents. These are sub-disciplinary fields where evolutionary economic geography is more or less theoretically, conceptually and empirically unchallenged.

Thereafter, underlining the previous point, this research has tended to find support for the superiority of collaboration in respect of a variety of performance indicators, and clustered co-operation for innovation being supported more by the collaborating part of the firm sample than the respondent group as a whole. This broadly applies in ICT and biotechnology, but as we have seen less regarding clustering for innovation activity by ICT than biotechnology firms, and much more for research interactions by biotechnology than ICT firms.. Research in ICT is less of a cluster-driver than innovation activity, but the latter is not as pronounced as supply-chain innovation stretching globally and intra-firm interactions, the latter partly a function of differing firm-size between the two samples. The one thing that appears to be almost

transparent, especially in the ICT data, is the superiority for firm performance of collaborative knowledge exchange and innovation activity over stand-alone competition, even for the large, dominating firms in biotechnology though possibly somewhat less for ICT firms, a few of which made it into the UK ICT respondent group.

Finally, there is a broad research agenda arising from this chapter in relation to the evolutionary economic geography of clusters but space only permits the elaboration of three sub-fields. The first and still unanswered issue concerns 'cluster emergence'. In other words how can it be convincingly demonstrated that some embryonic spatial agglomeration has reached the point when it can be said to be a cluster? There is obvious leverage from solving this problem from the academic and, particularly, the policy perspectives. Is 'critical mass' an appropriate notion, what does it mean, and how can it be measured in ways that have wide applicability? Could evolutionary game theory be a means of probabilistically modelling cluster emergence? Finally, given clusters are defined in terms of their networks, distinguishing them from agglomerations that lack such dynamic spillovers is cluster emergence best understood by application of evolutionary network theory (e.g. Cantner & Graf, 2006)? A second sub-field of great relevance to the fuller understanding of asymmetries in regional evolution centres upon the idea, introduced in Cooke 2008a and tested empirically to a limited degree in four case-settings concerns spatial variability in the presence of Jacobian Clusters, and for that matter MAR Clusters, and finally no clusters. Could the cluster mutation evolutionary process be a key to regional prosperity arising from proximate related variety. In the studied cases it seems to be so. In North Jutland particularly, it has a recorded beginning with Jutland's regional innovation through 'railroadization' (Schumpeter, 1975; Kristensen, 1992) in the nineteenth century. The path dependencies identified through cluster mutation are as follows:

- Clean technology is path dependent upon agricultural and marine engineering (e.g. wind turbine blades replicate plough and propeller design) near Aarhus and Aalborg
- Biotechnology (BIOMEDICO) is path dependent on Wireless ICT (NorCOM) and Medical Technology at Aalborg University
- Wireless technology is path dependent on traditional ship-to-shore marine technology

- Agro-food became established with the ‘railroadization’ of Jutland; organic agro-food is a reaction against conventional intensive food production in Jutland (mostly pig & dairy)
- Furniture is path dependent on ‘railroadization’, craft schools (350) and the local forestry tradition
- Fashion clothing evolved for women from craft schools skilling farmer’s wives in textiles
- Modern fish equipment and pipework engineering is path dependent upon traditional fishing and marine engineering centred on Aalborg

A version of co-operative entrepreneurship with high social capital characterised the enterprise model of the Jutland pioneers and this has evolved modern forms of collective entrepreneurship to the present day. Finally, what are the key policy mechanisms that usefully assist cluster emergence and evolution? The evaluation of eight VINNOVA Vinnväxt Programme cluster-building projects in Sweden suggests some common themes. Amongst the most important and frequently observable of these are: a pre-existing emergent agglomerative phenomenon; associative governance, leadership and finance; growth markets; and ‘ahead of the curve’ research and innovation knowledge (Cooke, 2008c). These mini-innovation system ‘clusters’ range from agro-food, through steel, robotics, industrial controls, robotics and fibre optics to healthcare services and biotechnology. Hence this is a robust test, conducted after the third year of cluster existence but it is unclear whether all will survive and whether there is Swedish exceptionalism or maybe a new ‘Swedish paradox’ if all or any do. Hence there is a need for evaluative research, possibly utilising Reference Class Forecasting (Flyvbjerg, 2008) to assist. This uses evolutionary evaluative modelling to establish actual costs and successes or failures of projects rather than traditional *ex ante* cost accounting models that habitually over-run predicted costs and performance estimates.

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