The role of research in regional innovation systems: new models meeting knowledge economy demands

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Abstract: Today, innovation systems are being elaborated in ever-wider areas of national space-economies. Of particular interest is the growth of academic study and practical policy towards assisting formation of regional innovation systems. Over 100 of these empirical studies have been documented worldwide and in the EU over 100 regional innovation strategies were implemented in the past decade. But new pressures upon existing innovation systems are coming from a globalising knowledge economy that favours metropoles and eschews peripheries. Now, new approaches to tackling innovation deficits are emerging ground-up in Europe that give insight into the real nature of competitiveness and the interlinked roles of science, research and innovation for the future.

Keywords: regional innovation systems; boundary-crossing; research-led models; knowledge economy; governance.


Biographical notes: Professor Phil Cooke is Director of the Centre for Advanced Studies, Cardiff University. He researches, writes and advises on innovation and economic development. He was in 2003 adviser to UK science minister Lord Sainsbury’s UK Innovation Review Panel. In 2004–5 is rapporteur to the EU expert panel on ‘Universities & Regional Development’ and chairs the expert panel on ‘Constructing Regional Advantage’. He also advised OECD and UNIDO on the ‘Regional Knowledge Laboratory’ approach to cultural and economic development in 2002. With colleagues at the Centre and in six EU and N. American countries, he is in 2004 embarking on a new project to discover the importance of ‘Talent’ to economic growth. Further new research includes an EU FP 6 STRP on Territorial Knowledge Management and an Atlantic InterReg project on ‘SME Innovation Capabilities’ with partners from Iberia, France, Ireland and UK. In 2004 he co-edited Regional Innovation Systems (Routledge; 2nd. Edition) and Regional Economies as Knowledge Laboratories (Edward Elgar). A special issue of The Journal of Technology Transfer (with Loet Leydesdorff) on Regional Development & the Knowledge Economy is published early 2005.
1 Introduction

Today, the concept of ‘Innovation Systems’ is widely used in discourse and policies to stimulate economic development through upgrading firms for enhanced competitiveness. Productivity increments are the key to enhanced competitiveness, and innovation is believed to account for a substantial measure of productivity gains in most of the world’s leading economies. So creating and sustaining innovation is perceived as key to improved competitiveness. Much the early knowledge about these relationships was derived from writers updating and correcting some of the crucial insights of Schumpeter [1] on innovation and entrepreneurship. These new thinkers utilised the notion of the national economy as their canvas, seeking to understand if it retained force under conditions of globalisation [2–3] although subsequently the difficulty of limiting the scope of analysis in that way was recognised [4]. Hence the importance of sectoral and regional innovation systems was highlighted. With regard to sectoral systems, interesting use of the ‘system’ concept developed, as in the work of Teece [5] and as ‘technological systems’ [6]. That firm-focused approach sought to show the detailed repercussions of an innovation upon the internal and external relations of the firm, its technology, skills-mix and marketing in the specific sector in question. This is an important future direction for research as the role of knowledge and inter-organisational networking expertise come to the fore in understanding the centrality of firm capabilities to business and wider economic growth [7–9].

In the Neo-Schumpeterian literature a more institutional idea of innovation is deployed. Innovation is the process whereby exploration knowledge, or research possibly leading to discovery or invention, is transformed by the application of exploitation knowledge into commercial products, processes and services that have market value. The term ‘systemic innovation’ denotes interactive linkage between generators, diffusers, exploiters and commercialisers of new knowledge. These are research centres, publishers and patenters, entrepreneurs, investors and marketers operating in an open techno-economic network in a given space such as a region or nation. It is thus a macro-concept capturing an institutional system rather than a micro-concept referring to repercussions of innovation on firm organisation. In institutional terms, systemic innovation is the means by which a range of national or regional assets such as laboratories, firms, government agencies, business associations and other intermediaries leverages added value which, by virtue of collaboration, is greater than the sum of the parts. Hitherto, innovation systems thinking has institutionalised research in large, amorphous entities like universities, public laboratories, industry, government and so on. This paper argues that is no longer an adequate way of conceptualising research in systemic innovation processes.

Also implied in this perspective is a rejection of the undersocialised notion of the market, competition and human action embodied in neoclassical economic theorems. Because of the need to understand the real nature of exchange in markets as a profoundly social process rooted in trust, reputation, learning and norms of reciprocity, the role of cooperation in successful competition is highlighted. It is argued that economic actors develop trustful interaction across different cognitive worlds, such as business, government and academe, in order to be competitive today. Without the formation of social capital linkages of this kind, (social capital being defined as trustful, reciprocal exchange, including exchange favours), systemic innovation cannot evolve, institutional assets remain idle and learning is impeded. This is captured in the following quotation from an official UK inquiry into the new demands of by firms of research:
“.....they are moving away from a system in which most of their R&D was done in their own laboratories, preferably in secret, to one in which they are actively seeking to collaborate with others in a new form of open innovation.” [10,p.3]

Hence, the contemporary challenge is to establish growth conditions at the level of the economic ‘milieu’. This is the combination of institutions as rules of the game, and organisations as the delivery mechanisms for improved economic performance that facilitates collective learning for fostering generative growth. Generative growth is endogenous but systemic not individualistic as neoclassicism insists.

In this paper, there are three main sections following this introduction. Section 2 consists of an extended discussion of recent thinking about and experience of regional innovation systems. Since the early statements [11–12] this latter emphasis has risen meteorically up the academic and policy agendas, with over 200 studies having been published 1987–2002, 103 of them empirically researched [13]. In the policy field the EU, OECD and UNIDO have realised studies and actions on regional innovation systems and national organisations such as Sweden’s new Innovation Systems Agency, VINNOVA, as well as regional (e.g. Northern Ireland Economic Council, 2001) projects have developed strategies to enhance regional innovation. The reason is the discovery of the importance to innovation of regional clustering and localised firm concentration as the means by which globalisation through producer or buyer value chains is organised on the ground [14].

But network connections among firms and with support agencies, of which clusters are a special condensate, do not operate in an institutional vacuum; rather they are to be understood as informally or formally associational in nature (see, for an early treatment of ‘geographies of association’, [15] and more recently ‘economies of association’, [16]. This means they have developed, to a certain degree, trustful, reciprocal research interactions with other actors of consequence locally and beyond. They have therefore recognised the importance of localised and globalised linkage (to outside networks) and leverage (including synergies with governance bodies, as theorised by Woolcock [17]). Such socially interactive processes may clearly be observed in the experiences of firms in innovation programmes to exploit research where firms are actively engaged in collective pecuniary and non-pecuniary interaction in and around markets [18–19].

Section 3 focuses on the governance, or functional support system of public and private research intermediaries now understood to be of central importance to the health of innovation systems and the clusters that may be embedded within them. Exemplars that illustrate the shift in posture for regions faced with knowledge economy research imperatives were selected as follows. Three types of regional innovation system, with varying modes of research engagement illustrate the decentralised (Tuscany), integrated (Baden-Württemberg) and centralised (Finland) approaches to regional innovation. Then, exemplars of new approaches provoked by recognition of the likely fate of regions that had yet to engage with research for innovation were selected for comparison, the rationale for this selection being indicated in the next paragraph. The key postulate is that newer systems will necessarily engage in catch-up learning since they are defined by their need to gain access to research for innovation. But they will rely less on codified, ubiquitous knowledge generated and processed in the leading economic centres in the world, more on tacit, endogenous research and ubiquitous codified knowledge combined. Knowledge transfer of that kind is central to innovation systems at national and local-regional levels [20]. Recent studies of Silicon Valley [21–22] are united in showing just
how important, even in mature systems, ‘knowledge brokers’ like legal and investment firms are to the generation and survival of new business enterprises and their subsequent stages of growth. Indeed, distinctive knowledge of boundary-crossing agents is key to the transformation of research exploration into commercial exploitation. ‘Knowledgeable attorneys’ in this context may act as gatekeepers, counselors and contact-providers, selling linkage often in exchange for equity instead of fees, while venture capitalists knit together clusters by encouraging inter-trading among their equity cross-holdings, based on learning from the Japanese keiretsu system. In less accomplished regions such actors also exist as local agencies substituting for abundant market transaction opportunities. Elsewhere this has been presented, independently of Winter [23] as the difference between entrepreneurial and institutional innovation systems, whereas Winter referred to entrepreneurial and institutional technological regimes [24].

Section 4 explores this question of governance in further depth. New examples of innovative regional governance of innovation systems grappling with the exacting demands of the ‘knowledge economy’ are presented. These were selected as follows. For comparability, an effort was made to include instances from the same or similar countries and regions as in the first, more mature set, i.e. for decentralised research exploitation for innovation, Italy, and specifically Tuscany, proved viable. For networked, integrative research exploitation, Finland showed more potential than Germany, where top-down, federal innovation initiatives like BioRegio for biotechnology and InnoRegio elsewhere, rose to prominence. Finally Denmark, where centralist intervention is pronounced and regions have no administrative existence, nevertheless stimulated regional innovation that engaged research and the social economy in significant and innovative ways. These cases showed new questions arising from the requirement for improved linkage between globalising forces and regional clusters involving multi-level governance, especially in respect of Scientific Research Systems (on this, see [25]). The new material reported in Section 4 has found a growing recognition that knowledge economies produce severe regional inequality. In particular the allocation of scientific research expenditure to a few elite research universities that also develop clusters in biotechnology and ICT (possibly in future also nanotechnology) means that without mobilising a regional response to design competing innovation systems, regional economic futures and fortunes will be threatened.

In Table 4, each main region discussed is represented, albeit somewhat inadequately in some instances. From the first set, Stuttgart rather than its land is the EU regional statistical unit (NUTS 2) for comparison, and Denmark, as noted, has no regional units. Turku is in Etela-Suomi, Seinäjoki in Väli-Suomi, and Oulu in Pohjois-Suomi. Tuscany appears as the administrative and statistical region it is. Most of these have over 40% of their workforces already in knowledge economy employment, a marker that they can be considered ‘knowledge economies’ in their own right (cf. [26] for whom 30% is sufficient to qualify such places in the USA as ‘creative class’ locales). Väli-Suomi falls just under 40% although local knowledge puts Seinäjoki lower, given Vaasa’s stronger impact on the regional score. Hence the local collaborative policy effort to engage more fully with the knowledge economy by embedding research in the sub-region. Tuscany’s score is very low, as it is for many European agro-tourism regions (see [27]), only marginally ahead of the Mezzogiorno. In the past, Tuscany’s and to a lesser extent rural Väli-Suomi’s disinterest in research for innovation system-building could be justified by the reasonable buoyancy of their small firm sectors selling on national markets. But globalisation has shaken such assumptions, leading to a rising interest in more knowledge-intensive competition.
2 The idea of innovation systems

What are the main findings of studies of European regional and national innovation systems and what changes in context must be attended to where global value chains are integrating in new ways with regional clusters? These are summarised in Table 1. In interpreting this and other stylisations of complex processes of systemic innovation it is vital keeping in mind that the ‘systems’ in question are by no means closed but open. This means they are porous to linkage with actors and policies involving other national system elements and supranational ones. Moreover, ‘innovation’ (unlike invention) refers only to the commercialisation of new knowledge rather than its discovery. Hence the leading research centres in the public and private sectors engage in dialogue with users, producers and intermediaries to help create, through successive iterations, commercial products and services for sale on global markets.

Table 1 Regional and National Innovation Systems: key findings [16]

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Innovation systems characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovation</td>
<td>Economic performance benefits significantly from incremental not only radical innovation.</td>
</tr>
<tr>
<td>Productivity</td>
<td>Transmission of scientific research into firms by recruitment and knowledge transfer is key to growth.</td>
</tr>
<tr>
<td>Linkage</td>
<td>Social interaction through research networks is key to innovation success.</td>
</tr>
<tr>
<td>Markets</td>
<td>Innovative customers play a crucial role in the innovative performance of firms.</td>
</tr>
<tr>
<td>Governance</td>
<td>Innovation is not a hierarchical, linear process but a consensus-seeking learning process.</td>
</tr>
</tbody>
</table>

Now, while these findings are generally cognate between both national and regional level analysis, what added value does a regional innovation systems perspective and analysis of actual cases bring to this approach? This arises from the conception of ‘region’ as a sub-national level of governance, public and private, with administrative and technical assets for promoting and enhancing innovation. The capability the regional approach provides for recognising diversity in the ways that innovation occurs in different settings is the source of its superiority. This means it rejects a ‘one size fits all’ innovation strategy of the kind that is difficult to avoid by central government. More importantly, it allows for the sectoral distinctiveness of regional clusters and the variety associated with the global value chains with which they are increasingly integrated. A conceptual illustration of the variety of types of regional innovation system (RIS), derived from the 100 or so empirical case studies referred to above is provided in Table 2.

Table 2 Typology of regional innovation systems and key action impulses

<table>
<thead>
<tr>
<th>RIS Action &amp; type</th>
<th>Grassroots</th>
<th>Integrated</th>
<th>Dirigiste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiation</td>
<td>Local</td>
<td>Multi-level</td>
<td>Central</td>
</tr>
<tr>
<td>Lead funding</td>
<td>Proximity Capital</td>
<td>Partnership</td>
<td>National</td>
</tr>
<tr>
<td>Research</td>
<td>Applied</td>
<td>Mixed</td>
<td>Basic</td>
</tr>
<tr>
<td>Innovation</td>
<td>Near Market</td>
<td>Up &amp; Downstream</td>
<td>Upstream</td>
</tr>
</tbody>
</table>
Table 2  Typology of regional innovation systems and key action impulses (continued)

<table>
<thead>
<tr>
<th>RIS Action &amp; type</th>
<th>Grassroots</th>
<th>Integrated</th>
<th>Dirigiste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialisation</td>
<td>Variable</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Reg. cooperation</td>
<td>High</td>
<td>Networked</td>
<td>Low</td>
</tr>
<tr>
<td>Coordination*</td>
<td>Market</td>
<td>Associative</td>
<td>State</td>
</tr>
</tbody>
</table>

*Entrepreneurial versus institutional

Source: Adapted from [28]

This displays the RIS concept as developed in theoretical terms and tested in a wide range of empirical analyses conducted initially in Europe (including the East, see [29]) but also in Asia [30–32] and North America [33–35]. The actions associated with systemic innovation are on the vertical axis and are self-evidently key interactive links in the ‘innovation chain’ [36]. On the horizontal axis are three conceptual systems, discussed extensively in [11,28] to be distinguished from operational or ‘real’ systems [37–38]. The Grassroots type may be understood as an abstracted version of the knowledge-based high-tech cluster or even the Italian ‘industrial district’, the Integrated type is more Germanic, where concertation between regional governance and industry is pronounced and, the Dirigiste is centralised, rather in the French manner.

In Table 2, key elements of the schema are refined to embody seven key types of action, such as the initiation, lead funding, research, sectoral specialisation, and cooperation involved in development of innovation activity aimed at building systemic linkage to local and global value chains. These vary according to the character of multi-level governance (MLG) in the countries to which the regions belong. Putting this schema to the test in Europe (East and West) revealed reasonably strong robustness. Thus, regions such as Tuscany and Emilia-Romagna, despite their own political specificities (‘workerist’ and ‘decentralist socialist’ respectively) fell in with the ‘grassroots’ regional profile for innovation policy and practice. Their ‘industrial districts’ are classic clusters, including informal governance systems based on local resource networks, fast market response and constant, often cooperative, upgrading. Investment capital comes from local banks and may be reputation-based with community notables verifying reliability and trustworthiness. Regional government in Emilia-Romagna acts as facilitator and animator of actions to enhance competitiveness and innovativeness in global value chains by co-funding skills upgrading and innovation service centres. This is less the case in Tuscany where local associations of entrepreneurs manage upgrading.

What the schema refers to as integrated and even dirigiste cases exist. The former category typifies certain länder in Austria, like Steiermark (centred on Graz) and Baden-Württemberg in Germany where ‘concertation’, close public-private partnership and policy networking operate horizontally across the region and vertically in terms of multi-level governance of innovation. Dirigisme is strong in, for example, Midi-Pyrénées, where the dominant aerospace industry is centred in Toulouse and innovation is dependent on multinational consortia and public funding for basic research. Eastern European regions like Féjer in Hungary and Lower Silesia in Poland have dirigiste past trajectories that are changing, the first accommodating significant FDI, the second, modest rates of endogenous entrepreneurship. They have little innovation or enterprise support fabric in their region, practically all is centralised in Budapest and Warsaw.
Hence they are not yet integrating markets and policy interactively, a key marker of regional systems as such, but parts of weak national innovation systems.

3 Varieties of regional innovation governance

3.1 Governance models

Traditionally, many European regions have leaned towards a dirigiste policy culture, partly because of market failure, such as industrial decline or maybe due to a history of management of large investment projects in partnership with bilateral or multilateral aid agencies that are part of the MLG system. However, today, with the rise of global value chains and regional clusters as key organising principles in the economic order, this is not enough, as Table 3 shows. To explain what has happened in research funding in simple terms, in the past development-planning phase, a top-down model of public project funding and implementation became the norm. This still exists, but now such hard infrastructure projects are being supervised by soft infrastructure initiatives to build platforms for integration of regional clusters with global value chains [14]. Such strategies may be initiated and adopted by governments independently, with multilateral agency support or by virtue of market transactions initiated by TNCs seeking competitive advantage from leveraging local assets.

<table>
<thead>
<tr>
<th>Policy action</th>
<th>Investment project</th>
<th>Innovation</th>
<th>Clustering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>Hydro Scheme</td>
<td>Supplier Upgrading</td>
<td>Inter-trading</td>
</tr>
<tr>
<td>Initiation</td>
<td>Multilateral</td>
<td>TNCs</td>
<td>Market</td>
</tr>
<tr>
<td>Lead Funding</td>
<td>Aid Agencies</td>
<td>MLG/TNC</td>
<td>Local Regional</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>State Labs/TNC</td>
<td>TNC</td>
<td>Local Associative</td>
</tr>
<tr>
<td>Innovation</td>
<td>Basic Incremental</td>
<td>Interactive Learning</td>
<td>Learning-by-doing</td>
</tr>
<tr>
<td>Specialisation</td>
<td>Sector-specific</td>
<td>Global Value Chains</td>
<td>Local Value Chains</td>
</tr>
<tr>
<td>Reg. Cooperation</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Coordination</td>
<td>State</td>
<td>Governance Network</td>
<td>Market/Associative</td>
</tr>
</tbody>
</table>

This brings into play two new sets of actors whose institutional base must be built through learning from experiences of RIS and cluster formation elsewhere and as represented in Table 3. The two new institutional actors are

1. *regional governance*, associated with the more sensitive design of policies and animation of research networks in line with regional economy sectors and specificities

2. *local-regional clusters*, the particularities of clusters are highly-attuned to market transactions, clusters are difficult if not impossible to design by policy, especially from a zero base, and they have certain demands for collective action (animating information flow, marketing the cluster, articulating skills needs to colleges, organising common purchasing) that are often most satisfactorily tackled by a cluster *association* with membership fees, limited staff and budgets.
Stimulating the formation of associative governance is a key task for regional bodies pursuing the objective of developing a RIS.

3.2 Tuscany’s innovation from below entrepreneurial system of innovation

Although Tuscany has, along with Italian regions in general, a regional administration, it has not had a history of intervening in innovation support services, nor has it implemented regional policy in support of innovation unlike, for example, neighbouring Emilia-Romagna.

Moreover, as Table 4 shows Tuscany has a low ranking in knowledge economy employment compared to most other EU regions. We shall see in Section 4.1 how ground-up efforts have been made to moderate this less-than-accomplished position using research.

Table 4  Selected regions from knowledge economy index

<table>
<thead>
<tr>
<th>Region</th>
<th>&gt;40% Knowledge Economy</th>
<th>Region</th>
<th>&lt;40% Knowledge Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU Position</td>
<td>EU Position</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stockholm (S)</td>
<td>58.65 (1)</td>
<td>Gelderland (NL)</td>
<td>39.99 (87)</td>
</tr>
<tr>
<td>London (UK)</td>
<td>57.73 (2)</td>
<td>Väli-Suomi (Fi)</td>
<td>39.10 (101)</td>
</tr>
<tr>
<td>Helsinki (Fi)</td>
<td>51.50 (11)</td>
<td>N.E. Scotland (UK)</td>
<td>38.09 (106)</td>
</tr>
<tr>
<td>Stuttgart (G)</td>
<td>48.84 (19)</td>
<td>N. Ireland (UK)</td>
<td>37.31 (107)</td>
</tr>
<tr>
<td>S.W. Scotland (UK)</td>
<td>47.59 (24)</td>
<td>Pais Vasco (Sp)</td>
<td>36.30 (115)</td>
</tr>
<tr>
<td>Denmark (DK)</td>
<td>47.46 (27)</td>
<td>H. &amp; Islands (UK)</td>
<td>34.45 (132)</td>
</tr>
<tr>
<td>Pohjois-Suomi (Fi)</td>
<td>44.50 (51)</td>
<td>Cataluña (E)</td>
<td>33.48 (137)</td>
</tr>
<tr>
<td>Wales (UK)</td>
<td>43.39 (56)</td>
<td>Navarre (Sp)</td>
<td>32.06 (145)</td>
</tr>
<tr>
<td>Ètela-Suomi (Fi)</td>
<td>42.25 (66)</td>
<td>Toscana(I)</td>
<td>29.75 (158)</td>
</tr>
<tr>
<td>S.&amp;E. Ireland (IR)</td>
<td>40.18 (86)</td>
<td>Aegean Islands (Gr)</td>
<td>12.70 (188)</td>
</tr>
</tbody>
</table>

Source: Eurostat: Regions: Yearbook, 2001; [27]
EU knowledge economy index, Cardiff, Centre for Advanced Studies

Non-intervention was largely a political choice of a centralist, communist political tradition favouring large enterprise that could be controlled to some degree by labour movements, or public enterprise similarly exposed to influence of the worker interest. Scientific research was not considered a relevant priority, even in established universities. Small firms were perceived as anachronistic, exploitative and, in policy terms, undeserving of special treatment. These, however, thrived under the influence of this not entirely benign neglect as many writers from the region show, notably for detail, Dei Ottati [39] writing in the intellectual tradition of Becattini [40].

What characterises distinctive clusters in this region, ranging from textiles to furniture in specialisation, are the following. First, social and institutional factors contribute extra innovativeness and productivity through knowledge spillovers giving firms competitive advantage and leading edge positions from this social context. In Penrosian [7] fashion, incremental innovation thus relies first and foremost upon firm capabilities derived from knowledge networking. Quéré [9] notes that in the Foreword to the 3rd edition of Penrose
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[7], published in 1995, Penrose asserts that had the economic language and conceptual apparatus been available at the time, the resources that she showed then to lie at the heart of business growth would nowadays be termed by her as knowledge network capabilities. Fundamentally, these arise not only from research but also from capabilities of skilled workers and entrepreneurs inside and outside the specific firm devoting their expertise to incremental innovation and diversification to meet ever more exacting customer demand. Hence innovative customers exert user-power on innovation creating demand for social interaction through networks (recall Table 1).

As Dei Ottati [39] puts it, this “cannot be obtained merely by means of bureaucratic controls, or even monetary incentives” (p. 450). But rather, as a second condition, openness and willingness to share and recombine knowledge in a context where – given the particularities of this region – the incentive is to meet customer demand without polarising income distribution. Success is defined in terms of excellence shared. This is, of course, unusual if the hegemonic view of entrepreneurship as individualistic competition and rivalrous contests is allowed to predominate. But, as noted, research on social capital and markets (see [41–42,19]) shows that even in countries and regions other than those in Italy, especially Tuscany about which Dei Ottati mostly writes, small and medium enterprises typically do not function according to neoclassical theorems of rational utility maximisation. Rather they do business and sometimes do non-pecuniary favours for networks ranging in membership from trusted acquaintances to family and friends. From this empirical perspective social capital may be said to constitute such markets:

- the dominant relationship is among individual firms
- more generally, firm networks of trusted, risk-spreading acquaintances also exist
- contract negotiations typify business aspects of such inter-firm and network links
- there is a necessity to do business with untrusted, unpredictable large customer firms
- suppliers perceive such customer links as more ‘neoclassical’ types of relationship.

Third, at the inter-firm level such ground-up capability for innovation derives from the interaction of three categories of knowledgeable worker. The first of these is the self-employed or employed workers whose knowledge capabilities reside principally in codified knowledge. Such labour possesses documented and documentable book and other transferred knowledge as the basis of expertise upon which the second and third categories of capability rest. The second category, combining mostly codified and some tacit knowledge are those firms or workers engaged in specialised phases of production like laminating, cutting or joining a variety of materials. The final category of knowledge expertise, largely tacit and to only a limited extent codified, relates to specialised design and marketing firms that deal with the initial conceptual input and close the loop between customer demand and satisfaction of that demand. Creative knowledge based on cognitive skills of interpretation on the demand side and equation of interpretation with system capabilities on the supply side is also key to the envisioning of innovative possibilities.

Fourth and fifth, are the private market and public regulatory providers of infrastructural services. These range in the first instance from sources of finance and logistics to skills formation agencies, chambers of commerce and specialist enterprise
service centres. In the second instance this encompasses local government and its regulation of the built environment, environmental management and transportation infrastructure. Thus, even in entrepreneurial, cluster-based innovation systems there is an important but perhaps not ultimately determinant role for public goods, albeit of a fairly basic kind. But it is notable that the transformation of \textit{exploration} knowledge by means of \textit{exploitation} knowledge remains wholly in the market sector and in large measure in the hands of firms and workers with creative knowledge capabilities and networks. This is instructive because, as will be seen in the fourth section of the paper, which deals with the implications of the rise of the knowledge economy for the governance of regional innovation systems, it is two features:

1. Access to skilled and capable \textit{exploration} knowledge or research (Creative as well as Scientific) counts.

2. A socialised notion of innovation support equivalent to notions expressed in Nowotny et al., [43] regarding the contextualisation of scientific knowledge by socio-political concerns and the co-evolution of research and economy in relation to knowledge exploitation also characterises the contemporary era.

### 3.3 Baden-Württemberg: a network governance innovation model

Let us look in more depth at the evolution of governance of a once well-functioning regional innovation system in Europe that came to prominence after a period of massive warfare and was associated with state funded public projects. This is Baden-Württemberg in Germany, in 1952 a new governance system at sub-national level faced with a devastated economy, high immigration of impoverished refugees, but a tradition and economy culture of entrepreneurship and manufacture of light engineering products. Inspection of Table 4 below shows its industrial heartland in the Stuttgart sub-region to be among the EU’s top twenty knowledge economy locations.

There are five key features that explain the robustness of what, in Box 1, is referred to as a heterarchical or networked governance modality in this regional innovation system. These relate to:

- responsible self-governance
- knowledge generation
- global connections
- future shaping
- envisioning.

The first of these, responsible self-governance, arises from full utilisation of the powers of federalism, particularly that which promotes the principle of maximum devolution of appropriate powers to the lowest relevant governance level. Thus communities without strong general powers may have determining influence in specific fields such as resolution of environmental conflicts. In Baden-Württemberg it is common for ‘citizen’s juries’ guided by unaligned scientific experts to carry weight in determining whether, for example, their waste should be burned or buried as a matter of evolving policy. In a different sphere is the responsibility of Chambers of Industry and Commerce to design, certify and validate vocational training for the celebrated system of apprenticeship
training. This is true of Germany as a whole, not only this region. But it means that boundary-crossing institutional interaction is designed into the innovation system so that foresight regarding changing industry skills requirements is regionalised through Chamber to industry and college interactions and adapted according to regional industry mix.

Second, knowledge generation and a respect for pure and applied research, are deeply embedded in the institutional fabric of this region. Numbers alone are insufficient indicators of the nature and quality of services provided but they capture the richness and variety of supply. Thus, there are ten national and international class universities serving a regional population of ten million. There are 40 polytechnics, 14 Max Planck Institutes conducting specialist basic research, and a further 14 Fraunhofer Institutes conducting applied research. There are more than 100 industrial research institutes echoing specific regional interests, notably in engineering but also new industries like photonics, nanotechnologies and biotechnology.

Third, global connections are an integral part of the profile of a successful regional innovation system. This land has devoted attention to governance of international knowledge flows. Thus, in 1990, it was the architect of the Four Motors for Europe programme of inter-regional networking around science, technology and innovation interchange. This brought together in a functioning knowledge transfer partnership, the regional governments of Catalonia, in Spain, Lombardy, in Italy and Rhône-Alpes, in France. Shortly afterwards, Wales was invited to join followed by Ontario from Canada. However, this multilateral programme was preceded by a large number of bilateral agreements formed earlier with regional governments in places such as Kanagawa, Japan, Linowing, China, Michigan and Connecticut, USA and Quebec, Canada. These regions were carefully selected to mix and match the industry specialisations of the partners.

Box 1: Evolution of the Engineering Innovation System in Baden-Württemberg, Germany

Baden-Württemberg could be shown to be a clear instance of a heterarchical regional innovation system….firms had many vertical and horizontal, market and non-market, trustful and sceptical relations with each other. More than this, they had comparable relationships with intermediaries and government departments, who themselves worked through networks. Of course, in both dimensions, there were power relations; thus Daimler-Benz was able to animate and influence networks at the highest possible level inside and beyond the region. Equally, as the authoritative institution, the land government was more influential than any other public body set in the region. But that did not mean that actions important for innovation were only initiated by them, nor that those that were always succeeded. A fine instance of the latter was the land-initiated policy for Baden-Württemberg to become the first region in Germany or elsewhere in interactive television. A large budget was earmarked and leading large firms in telecoms, computing and TV were organised into a policy network. Small and medium-sized firms were not highlighted in this process despite critics’ arguments that ‘content is king’, the technology is not, and the innovative new media firms were in the mittelstand. Predictably telecoms firms (Deutsche Telekom) found it impossible to agree standards or much else with computing firms (IBM, Hewlett-Packard) and the TV company could not work with either. Hence the attempt to ‘create’ a new media network among global players in the region was a failure.
However, an alternative narrative can be provided where the networks already exist and a member highlights an innovation issue. The case concerns the early 1990s impact on the possible future industrial fabric by the advent of Toyota’s new luxury car, the Lexus. Keep in mind the land is home to Mercedes and Porsche and also had Audi in the region. Mercedes expressed its fears that it would be uncompetitive both to its industry association and the government. The reason was that Mercedes still designed and even produced far more parts and components in-house than the industry average in Germany. One way of reducing costs was to sub-contract responsibility for innovation to the supply-chain. This idea was discussed with the automotive trade association and the regional industry minister’s office. The ministry, on the advice of the association commissioned US consultants to explore the capability of regional mittelstand firms to take on an extra R&D burden. It transpired that most were used to receiving designs from the customer and producing to order, also few had R&D offices or staff. So to stimulate greater integration of innovation in the external system of production the ministry agreed to subsidise model projects in which suppliers would learn to innovate by interaction. Suppliers expressed fears that they would lose precious know-how to competitors, so agreement was reached that sensitive knowledge needed to innovate would be held by the Fraunhofer Institute acting as a trusted third party member of the project networks. The outcome was a more systemic regional innovation process and one that has contributed to the strengthening of Mercedes’ global competitive strength [44].

The key point here is that such interaction could take place rapidly because a variety of key players were present in proximity and accordingly were familiar with each others reputations and capabilities. Thus, as well as large customer firms and extended supply chains, there were numerous research institutes such as the Fraunhofer Society, well-equipped in applied automotive research, the Max Planck Institutes, if more fundamental research knowledge was needed, the regional branch of the German automotive industry association, the technology centres of the Steinbeis Foundation, scattered throughout the higher education system of the land, and numerous engineering and other technical consultancies The systemic nature of these nodes in the network could relatively easily be exploited given a challenge such as the one described.

Fourth, by careful tuning of these and other antennae, the governance modality of the region has been able to conduct system guidance through a collective process of future shaping. Thus instead of economic development policy being hierarchically constructed by the regional government, then issued for consultation before final promulgation, it was prepared through a responsible self-management governance modality. Starting in 1987, the master institutions drew up their first audit of scientific assets (such as those listed in point two above) with a view to developing a more knowledge-based economy. Then in 1993 the Future Commission reported, led by an industry association head and involving government, other industry associations, Chambers, higher education and research institutions, banks and business leaders. The aim was to assess the opportunities and pitfalls facing the regional economy up to 2000. Fears were expressed that it was too monocultural an industrial region with an over-emphasis on automotive engineering and inadequacies in science-based and creative industries. This influenced policy formation during the later 1990s that saw incentives given to commercialisation in nascent new media, biotechnology and photonics businesses [45].
Finally, the innovation system as described combines entrepreneurial and institutional modes of boundary-crossing. Both operate interactively and in their specific capability spheres, but they are also mobilised for instances requiring transparent interaction of key institutions of consequence to the economic future of the region, which is vision orientated. That is, it has a collective and widely disseminated identity and self-perception that makes constant benchmarking against other regions inside and outside Germany and Europe a key part of the management of change. Thus the past vision of a high quality automotive production region in which leading-edge technology applications maintained the region’s global lead in luxury car production, once achieved, quickly began to be modified. The key modification rested on a recognition that such a vision had led to costly ‘over-engineering’ of certain products, ranging in the 1990s from over-sophisticated machine tools that sold poorly outside Germany, to the Mercedes S Class saloon that in its first version was so over-engineered technologically that it failed to meet claimed performance indicators. So, global sourcing of adequate, cheaper systems and components began, and a vision of a higher quality design culture (influenced by learning from ‘Four Motors’ partner Lombardy and, particularly, Milan’s design tradition) formulated. Subsequently a ‘greener’ vision has been intertwined with this more sensitive, less engineer-dominated image.

3.4 The Finnish regional ‘Triple Helix’

In smaller economies, regions are less pronounced but actively being formed, especially as innovation and economic development delivery mechanisms. A case in point is Finland, which generally scores high on the regional knowledge economy index (Table 4), Helsinki being eleventh highest in the EU and where at least ten innovative clusters built around Science Parks have been established. Briefly, some of the more interesting are those in the far north of the Gulf of Bothnia near the Arctic Circle at Oulu, and the science-based clusters at Turku deserve mention. Both draw their origins from the Finnish national innovation system and its variety of public innovation support agencies, as shown in Figure 1.
These operate regionally according to a common model. Thus The Academy of Finland [46] report on *Biotechnology in Finland* notes how Oulu, capital of Northern Finland, first grew a successful university, then a successful ICT industry and an active support infrastructure for Life Sciences research and innovation, nowadays selecting Life Sciences as a research priority. Thereafter, Biocentre Oulu was the first to be established in Finland, funded by the Ministry of Education and Academy of Finland as a special
Biotechnology programme from the mid-1980s to boost Finnish activity in the field. Technopolis Ltd. runs the Biopark adjacent to the research hospital. It is an incubator funded by TEKES and Finnvera Ltd., a state-owned financing company with 16 regional offices. Currently an offer is out to VTT Biotechnology to establish a branch at Oulu to assist large-scale production methods for local biotechnology firms.

Turku (Etela-Suomi region in Table 4) also has a long-established biotechnology sector, dating from the mid-1980s. It is unique in housing BioTurku a regional research initiative focused on the city and promoted municipally, to manage the development process [47]. Thus BioTurku as a regional network governance modality was responsible with partners in establishing Turku’s BioCity incubation facility, modeled on the DataCity building constructed to house ICT start-ups. Since the beginning, and dependent on network evolution but always with the municipality and cooperating universities as prime movers, Turku has built itself up to be a significant actor in Finnish biotechnology. BioCity has now been joined by a new investment PharmaCity that aims to facilitate the exploitation of Life Sciences research in the form of therapeutic treatments.

Hence, the Finnish approach to regional innovation system governance was closer to dirigisme than bottom-up but with a distinctive multi-level concertation, based on a combination of strong central vision and local leadership. The key combination in both cases was a ‘Triple Helix’ relationship between universities, industry and government ministries or innovation support agencies. This differs from the German model, which is more diffuse, with many different network members, possibly less dependent on the driving force of a key agency like TEKES or VTT. Accordingly, the Finnish model, promoting also Centres of Excellence, was quite consistent with radical innovation as well as supporting incremental innovation in well-understood technological fields. Finally, peripheral countries often lack developed venture capital markets, so it is interesting to see how public companies were set up for that purpose and function as a substitute, compensating for market failure. However, the Triple Helix also offers a form of subsidised ‘infant industry’ protection for start-ups, not least because of the presence on most Nordic Science Parks of large customer firms like Nokia, Orion, and Danisco. Nevertheless, these localised Triple Helixes have in the past assisted the Nordic countries to stay at or near the forefront of European innovation.

4 Regional innovation systems in the knowledge economy

4.1 How do we measure the knowledge economy?

A key question raised in Cooke [24] which comments on the evolution of a range of regional innovation systems from the beginning of the 1990s through to the early 2000s is the following. Are the innovation systems that developed early, in some regions in partial or fragmented form while elsewhere as more integrated, information diffusing and technologically supportive set-ups, any more suitable for their indigenous regional economies or as models for other kinds of regional space-economy lacking but aspiring to promote regional innovation systems? In other words, do regional innovation systems atrophy, perhaps because of the tension between system, which is stabilising and innovation, which represents change? In economic downturns do new boundary-crossing problems arise that may privilege institutional stabilisation as markets penalise entrepreneurship even though firms may continue seeking innovation? The broad answer
to this is in the positive, and just as market-adjustment to promote different combinations of innovations struggles to find new buyers, so pari passu does this apply to innovation support institutions of regional innovation systems. The reason for this is that new pressures are being experienced by all regions consequent upon global economic recession, the flight of manufacturing jobs to developing countries, and recognition that the only reliable response is to engage fully with research as a means to embedding the Knowledge Economy.

Our definition of the Knowledge Economy is “an economy in which more than 40% of employees are employed in high technology manufacturing and knowledge-intensive services”. This statistic is not arbitrary but rather based on an in-depth study of regional employment composition in the European Union. It is based on a relatively widely adopted calculation [48] and is highly appropriate for analysis of regional as distinct from national economies. This is because some 43% of EU regions score 40% or more in a regional ranking, the EU Knowledge Economy Index, developed by Cooke & De Laurentis [27] and as can be seen from a selection of regions above and below the 40% line (Table 4) such a demarcation seems reasonable. Of course all such demarcations are open to debate but it is significant that many regions scoring below 40% are in the economically less favoured areas of the EU while few regions in receipt of, for example, Structural Funds Objective 1 support are found in the upper 40%. It is worth noting that the Knowledge Economy is highly imbalanced spatially, being most pronounced in regions with a significant urban component to the population.

4.2 The Pisa model: extramural regional knowledge transfer

An inspection of Table 4 shows Tuscany as having one of the lowest knowledge economy after and scores at 29.75 in the European Union. As well as strengths that come from the creative combination of tacit and codified knowledge among occupational and broader communities with accomplished knowledge capabilities and networks, Italian-style clusters have a debilitating potential weakness. This is that they are less accomplished absorption agents for scientific and technological knowledge, the kind of exploration knowledge represented by research, in a national system of innovation that does not prioritise expenditure on innovation and whose universities are both ancient and recalcitrant in the face of ideas such as ‘Triple Helix’. Thus this sub-section and the two that follow each address the following question. How may regional innovation be pursued in institutional contexts where the ‘quasi-firm’ like nature of the university postulated by Etkowitz [49] is absent, where also large firms that are familiar with interacting with universities are largely absent, and where there is no ‘big government’? That is, there is neither regional nor national administrative presence of the kind implied by ‘Triple Helix’ thinking, only the municipal level exists, absent prestigious university and local oligopolies.

The first case briefly to be explored as a parallel of ‘grassroots’ or ground-up initiative successfully to promote innovation in a hitherto weak national and regional innovation context is that of Pisa in Tuscany, Italy, subject of a special benchmarking monograph from OECD [50]. The Pisa research, education and entrepreneurship system is integrated and supportive of localised and regional economic growth. Although it has the University of Pisa, which specialises in computing and engineering, Pisa’s smaller Scuola Superiore (translated as Institute for Advanced Studies) Sant’Anna (founded 1987) seems to be a more impressive actor for its size. The former has 2,000 teachers and
633 researchers, the latter has 150 staff who are all researchers, plus 120 on the PhD programme. In the Scuola, programmes are highly focused on the social and experimental sciences, albeit pedagogy is highly interdisciplinary and research has moved away from pure science to that of supporting innovation in commerce and industry. The Scuola makes special efforts to collaborate with other key research laboratories in Pisa, namely the National Research Council (CRN) with its 14 research institutes and 1,000 researchers in Medical & Biosciences, Natural Sciences, Computing and Environmental Sciences.

Three other national research institutes in thermal, environmental and nanotechnologies are also present and in interaction with both University and Scuola. However, as we have noted, for regional innovation systems to work well, boundary-crossing institutions are vital. Scuola itself has formed Pont-tech a knowledge transfer agency employing 15 specialising in scientific and technological transfer between research and firms. Two other ‘bridging’ institutions are operated by a consortia of firms and research bodies – Consortium of Pisa Research and the Quality Consortium. Aurelia is a technological innovation company operating in the knowledge transfer field. Its philosophy is social in inspiration in the sense it seeks to build inter-firm and agency relations based on collaboration as well as competition in a ground-up fashion reminiscent of the region’s traditional clusters. These ‘bridges’ transmit knowledge inwards and outwards to and from international networks and actors linking to regional equivalents. This has given rise to a concentration of as many as 6,000 firms operating in high technology fields in the wider Pisa-Florence northern Tuscany axis, some 2,000 in networking, electronics and other advanced technologies, and 70 spin-off research firms from the Pisa complex.

Of leading importance in this is the foresight, leadership, and knowledge-transfer capability of the newer, highly-specialised Scuola Superiore. For all its miniscule size, six successful spinout firms have recently been formed by graduating PhD students in robotics, systems design, biomedical devices and computing. A leading example of the ambition and dynamism of Scuola is its recent agreement with Marconi Group, CNR and CNIT the Italian Telecommunications Association, to establish a new research centre in photonics. Hence, the Pisa experience has shown how even when a relatively active established university exists in a locality, dynamic knowledge networking and action from a new, small entrant may be the extra research dimension needed to push forward in various fields of innovation. This has been perceived in the case of the Scuola Superiore’s Institute of Advanced Studies capability which, because of its high reputation in research and in assisting the shift of research from laboratory bench to market attracts attention from as well as giving rise to numerous of the boundary-crossing institutions needed if a well-functioning innovation system is to arise, especially in a national context that was not hitherto nurturing of such activity. Such is the perception of success from the Pisa model that it attracted interest and support from higher scale and the national government has promoted four experiments to transplant the Pisa Model to Puglia (Lecce), Umbria (Terni), Lombardy (Pavia) and Campania (Benevento) where Institutes of Advanced Studies are set up to bridge the boundary between exploration (research) and exploitation knowledge and advance Italy’s regional innovation system potential.
4.3 Epanet: remote Finland’s regional research exploitation system(s)

The main region of interest here is South Ostrobothnia, located in the wider Väli-Suomi area, which, it will be recalled, displays a ‘knowledge economy’ index score of marginally below the 40% magnitude that signifies reasonable abundance of knowledge economy employment (Table 4). However, the point to be reasserted is that knowledge economy characteristics concentrate overwhelmingly in cities, hence the main city of Vaasa on the west coast of Finland accounts for much of the region’s knowledge economy accomplishment. In the forested, agricultural interior centred on the town of Seinäjoki (30,000 population) concern about being excluded from Finland’s dirigisme in regionalising the national innovation system in a few growth points like Helsinki, Turku, Tampere, Oulu and Jyväskylä led to collaboration among municipalities adjacent to Seinäjoki around a Seinäjoki Regional Centre Programme. Younger key actors in devising the programme included economic development officers and academics in the Seinäjoki Institute for Regional Research of the University of Helsinki who were well-schooled in the concept and application of regional innovation systems and networks. Reference to the outreach nature of the Institute, affiliated to the University of Helsinki, gives a clue as to the policy route selected to integrate this remote S. Ostrobothnian region with the knowledge economy [51].

Through a network of affiliations, or filials as they are termed locally, the programme formulated and implemented the idea of buying 20 research professors who would be affiliated to any Finnish university that accepted the idea of affiliating free professors, and locating them in Seinäjoki. The professors, 14 of whom were in place by 2003, occupy premises in a centrally located former hospital, proximity facilitating the main vision of the programme, which is that they network with each other, they attract research income and they focus their own and their interactive research on issues of direct relevance to upgrading the knowledge capabilities and competitive performance of SMEs in S. Ostrobothnia. An obvious question is why would any self-respecting professor commit herself to this kind of self-exile. But the answer is to the contrary. Three features of this model underlie its success in forming this academic community.

1 These are young, newly-appointed professors who accordingly receive a career-boost.
2 They are affiliated to a university, the rule being that the research field is a new one not currently offered, and that they can return to base after a three or five-year contract terminates, unless it is renewed.
3 Such researchers have strong appetite for the freedom from normal university structures and duties a filial appointment gives them.

This last point is also extremely important theoretically and practically from the viewpoint of the programme and more generally. Whereas the Triple Helix argument argues for strategic institutional networking among solid structures like universities, industries and government – leading to the inference that regions without a university are doomed in the knowledge economy, the programme view is that what is needed is relevant, high-quality research. This is an almost Euclidian insight. There are none of the cumbersome sunk-costs, bureaucratic inertia and academic conservatism that can be, many would say are in fact, defining features of established universities, to be dealt with

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under the filial model. Hence the programme, now termed Epanet has leading edge filial research expertise in the following fields:

- Electronic business (filial of U. of Tampere)
- Healthcare IT (f. of Tampere U. of Technology)
- Logistics systems (f. of U. of Vaasa)
- Virtual technology (f. of Tampere U. of Technology)
- Consumer behaviour (f. of U. of Vaasa)
- Rural entrepreneurship (f. of U. of Helsinki)
- Entrepreneurship (f. of U. of Vaasa)
- Musicology (f. of Sibelius Academy)
- Software (f. of Tampere U. of Technology)

Further appointed positions are in:

- Management
- Food Chains
- Urban Competitiveness
- Laboratory Medicine
- Plastic Composite Technology
- Aluminium Technology.

With affiliations to the same universities already mentioned.

Research funding is accessed from regional, national and EU sources and is aimed at improving the availability and quality of the region’s knowledge base and information infrastructure, raising specifically firm capabilities in utilising advanced IT, developing IT services offered to firms, developing public electronic services related to e-government and e-healthcare, and contributing to the management and production of cultural content, notably popular and traditional music.

This model, with variations also operates in the region around Kokkola on the north Ostrobothnian coast near Oulu where the recruited research filials belong to and are housed in a single establishment named the Chydenius Institute (filial of the University of Jyväskylä). Moreover, as with the Italian examples of regional institutional transfer, other variations of the localised, ground-up approach to engaging with the knowledge economy by forming regional innovation networks, were noticed by the Finnish state and given its imprimatur. These and comparable initiatives exist in what are now six ‘University Centres’ (yliopistokeskus) in Finland, which according to the Ministry of Education are forms of educational cooperation, rather than steps towards new independent universities. These centres are supported by the Ministry of Education and were formally launched in early 2004. Thus the designated university centres are those of Kajaani, Kokkola, Seinäjoki, Pori, Mikkeli and Lahti. The official perception is that the University Centre of Pori is among the most developed. The Pori University Consortium is a centre of five universities which operate as a networked multi-science environment with about 1,200
students and 160 expert researchers and tutors. The networked universities are affiliates of Tampere University of Technology, Turku School of Economics and Business Administration, University of Turku, University of Art and Design, as well as University of Tampere. All of the preceding institutions have university status. In addition to these institutions and their research activities, advanced research is also conducted by the University of Turku, Centre for Maritime Studies and University of Tampere, Centre of Human Sciences Research and Development in Satakunta Region. (http://www.porinyliopistokeskus.fi/)

4.4 Digital North Jutland: the region as an innovation ‘Lighthouse’

Denmark scores relatively high on the knowledge economy index, but this masks the strength of Copenhagen in comparison to the rest of the country (Table 4). Nevertheless, North Jutland in Denmark has been at the forefront of mobile telephony infrastructure under the GSM standard since the 1980s. Many of its 60 or so start-up businesses spinning out from the technical departments of Aalborg Technical University established on the university Science Park and were then often targets for equity stakes or acquisition by the likes of Amstrad, Bosch and Siemens. These early mover firms exploited the Nordic Mobile Telephony (NMT) standard that preceded and thus pioneered GSM 2nd Generation telephony infrastructure. More recently, GSM 3rd Generation technologies, using Bluetooth interoperability systems have not only been a focus of new firm formation but also new acquisitions. Thus, virtually all 60 firms are owned by foreign investors like Analog Devices, Motorola, Flextronics, BellSouth, Ameritech and Texas Instruments from the USA, Cambridge Silicon Radio, Pre-tel Wireless and TTPCom from UK, and Infineon, Siemens and STN-Atlas from Germany [52]. Expertise in software engineering and development for video streaming, satellite and radio communications, and for technologies like GSM and Bluetooth is highly-prized globally because it is in short supply, especially in the USA which lags Europe considerably in mobile telephone technologies.

On this basis, the cluster in North Jutland has developed a leading technological position in wireless radio technologies more generally. Now research applications for 4G are being developed. 4th Generation telephony integrates wired and wireless telephony at very high speeds. Already Wireless Local Area Networks (WLAN) are available. These provide short-distance, high-speed internet access. This US technology depends on the presence of ‘hot-spots’ like hotels, airports, petrol and train stations, and cafés for access to be secured. Because the USA lags behind Europe in mobile telecommunications infrastructure, WLAN will enable that challenge to be met with a different technology. However, more likely, and capable of keeping the European lead, is a combination of wired and wireless technologies. Hence the developing expertise within this small regional innovation system that has as its governance system a core set of networks linking firms together using social capital, and firms to the university for intellectual capital, is wireless telecommunications hardware and software. But key to innovative capabilities is foreknowledge of market applications for wireless telephony.

Thus in February 2000 the Danish Ministry of Research & Information Technology designated North Jutland as one of two ‘IT Lighthouses’ [53]. This indicates a residual degree of dirigisme but also more inclusive, in that regional support was entailed, than that epithet traditionally implied. The nevertheless ‘top-down’ initiative was part of their ‘Digital Denmark’ programme to make the country a ‘network society’. A key measure
involved perceiving the region as a ‘developmental knowledge laboratory’. This meant conducting a large-scale regional experiment in North Jutland, paid one-third by the Ministry and two-thirds by regional authorities, local government and business to the tune of some Euro 50 million. The lighthouse experiment operates as a technology programme that funds specific applications projects. Significantly, these projects have four streams:

1. IT infrastructure
2. E-Science
3. E-Learning & Skills
4. E-Administration.

These were aimed at promoting organisational networking for enhanced knowledge capture and processing, and North Jutland’s response to opportunity was through ‘contextual’ partnership and an inclusive culture for enhancing delivery of healthcare, public administration and local government services, plus project-based e-learning. The first round of funding brought forth 55 projects in these and more technology-focused fields, the second round raised this number to 94.

It thus involves not only the techno-economic networks of the university and IT firms, but the community networks of consumers of health, local government, retail, transport etc. Thus it is an even fuller experiment in social inclusion to assist regional technology firms to find innovative markets by stimulating exacting user demand than the experiments in Finland. The two Nordic experiences have occurred between two rather differently composed regional innovation systems. In Finland, ‘knowledge networking’ is a means of speeding up the knowledge input-output and exploration-exploitation process. In North Jutland, knowledge transfer within the confines of 4G wireless telephony and, previously GSM software and services means technology supply exists but clear markets are less visible to firms than, it is presumed, ‘society’.

5 Conclusions

To conclude this paper, three issues are illuminated by the results of the research here reported. First, accomplished research-using settings are characterised either by well-functioning entrepreneurial innovation links from research to commercialisation, or intermediary research institutions that cross the exploration-exploitation knowledge boundaries. Thus most regions do not enjoy the density of innovation support services displayed in Silicon Valley. But neither do they suffer the wreckage of bankruptcy and 400,000 lost jobs consequent on an over-specialised, arguably over-innovative business culture. More normal in Europe are relatively stable institutional innovation systems where important intermediaries can be research institutes like those of the Fraunhofer Association in Germany. But Germany’s economy is stagnant and not famous for its ‘new economy’ innovativeness. Between these two poles lies a perfect innovation system, but it is not yet represented in the material discussed. This is because the new approaches outlined have yet to be fully tested.

Secondly, what the new approaches reveal is, on the one hand, a more direct quest to acquire research knowledge for social and economic application without, on the other
hand, the cumbersome policy-network bureaucracy of interminable meetings among macro-institutional representatives often rehearsing rhetorical not real positions. This clash of codes among ‘epistemic communities’ [54] is what ultimately weakens the grand ideals of the ‘Triple Helix’, as recognised by Etkowitz [49]. In this manner, the role of ‘enterprising bureaucrats’ is highlighted, as is their noticeable non-abundance, and a challenge for training in a new ‘research policy’ pedagogy [55]. Thirdly, discovery of the powers in facilitating knowledge diffusion among epistemic communities that arises with project-focused inter-professional networking, is the means of achieving near-perfection in boundary-crossing processes related to innovation. Galison (1997) referred to this as evolving ‘contact languages’ in what others refer to in discussing transdisciplinary research as ‘trading zones’ or ‘transition spaces’ [43]. Whether the capabilities displayed in these still-institutionally driven knowledge economy cases will founder in the face of inadequate supplies of venture capital or ‘knowledgeable attorneys’ remains to be seen. But ‘research policy’ and enterprising bureaucracy focuses on these issues too, and where there are market failures they substitute for the market until it wakes up [56].

Thus the exigencies of the Knowledge Economy linked to pressures of globalisation produce a more ‘contextuated’ [43] research-led model of a regional innovation system. This means that, instead of ‘knowledge networking’ being confined to the political and policy arenas as a means of engaging with the Knowledge Economy, the policy and technology arenas engage with the regional community, accessing their tacit knowledge to build a market for innovative products and services. This is clearly the manner in which the Pisa Model of Institutes of Advanced Study are meant to operate. Of particular general relevance in this of course are the University Centre filial research networks established in Finland’s peripheries. Thus networking from below has to some extent moderated the effects of dirigiste research concentration. Moreover, ‘lighthouse’ projects on wireless services stimulated by globalisation have caused the region of North Jutland to reconfigure network governance modalities and realign policy profiles. Box 2 attempts to capture key elements in the necessary ‘toolkit’ whereby enterprise support agencies may successfully engage with the Knowledge Economy ‘policy network’ approach. However, it is worth noting that the key Danish Ministry initiated the ‘Lighthouse experiment’ albeit by perceiving implementation through a ‘developmental knowledge laboratory’. Similar is the new valuation of scientific research and social capital in the Seinajoki Epnet system as resources by which knowledge creation capture and transfer may dynamise innovation. Thus it is evident that, given the changing conditions faced by regional innovation systems these pioneers in their different ways are mapping a new trajectory for policy in the burgeoning Knowledge Economy to which many new regional members will unquestionably be attracted in the short-term future.
Box 2: Regional Innovation Systems in a Knowledge Economy
‘Toolbox’

The Regional Innovation Systems (RIS) approach is built on the ‘interactive innovation’ perspective but goes beyond its ‘learning systems’ focus by stressing the ‘knowledge transfer’ aspects of the model. This makes it especially suitable in the context of the ‘Knowledge Economy’. This is becoming a key driver of economic policy formulation. This innovation systems toolbox is applicable nationally and regionally, but is particularly well-attuned to local regional implementation because it allows for regional institutional and sectoral variation rather than offering a ‘one size fits all’ approach typical of centralised policy formulation:

- As a development model RIS thinking places research, or knowledge exploration, and commercialisation, or knowledge exploitation, processes at the heart of the policy process.
- The model is holistic in its deployment of policy concepts and tools, and interdisciplinary in its overall perspective.
- The approach treats innovation as evolutionary, but recognises the importance of disruptive technological or organisational change that is not path dependent.
- Policy is designed to moderate the negative effects of ‘knowledge economy’ disequilibria while recognising the likelihood of unanticipated effects.
- The key sub-systems are knowledge exploration and exploitation. Capturing and commercialising knowledge requires a new research exploitation system. The rationale for a RIS is the promotion of growth, employment and competitiveness.
- The RIS institutional system has governance through social capital rules, conventions and norms for networking organisational actors like firms, investors, intermediaries and government.
- Innovation of many kinds is sought as an outcome of the operating RIS. Organisational innovation to improve efficiency and effectiveness, process innovation to enhance productivity and capacity to meet global market requirements, and product innovation to achieve continuous improvement in competitiveness.
- RISs can be regional or sectoral or combinations of these. Regional sectoral innovation systems and strategies are operationally most effective in practice on the ground. National policies for a generic sectoral approach are necessary to set the policy framework and set of incentive structures.
Box 2: Regional Innovation Systems in a Knowledge Economy ‘Toolbox’ (continued)

- A RIS has an ‘open systems architecture’ meaning it is open to knowledge and learning inputs from global sources and transmits system knowledge globally in turn. It is a ‘knowledge input-output system’ or ‘knowledge transceiver’.
- The RIS approach calls for innovation in organisational forms, especially those of government where ‘governance’ influences policy. Thus organisational actors of consequence to innovation access a more porous, less hierarchical, more heterarchical (networking) domain. This must extend also to key sub-system organisations and become systematic as a mode of overall co-ordination.

Source: Derived from [57]

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