The Regional Development Agency in the Knowledge Economy: Boundary Crossing for Innovation Systems

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Introduction

It has become commonplace to say that today we have entered a new phase of global economic development in which 'Knowledge Economies' are the most significant centres of growth and dynamism (Cooke, 2002a). It was easier to argue this in the years leading up to the ending of the ICT 'bubble' early in 2001 and many unethical sources for the inflating of that bubble have since been identified (Cassidy, 2002; Fusaro & Miller, 2002). Nevertheless, paradigmatic change transcends stock market booms and slumps, and the industries that underpin the Knowledge Economy are not limited to dot.com businesses. Far from it, for as the analysis in OECD (1999) on which statistics to be shown in Section 1 of this paper are based, the Knowledge Economy includes some traditional as well as high technology engineering industry, and some rather traditional public service industries like healthcare and education as well as R&D and media. Knowledge economy sectors such as those identified by OECD (1999) and modified slightly in EU (2002) and Cooke & De Laurentis (2002) show it is knowledge-intensive services that play the most significant role in the designation of knowledge economies. We will show how, in the EU, a cut-off point of 40% marks a realistic distinguishing point between Knowledge Regions (NUTS 2) and the rest, although all such markers are to some degree arbitrary.

Having displayed a version of the statistical make up of 'Knowledge Economies', the paper then moves in Section 2 to a consideration of the implications of this quite significant emergence of a differently composed, 'stylised' regional economy for the economic development 'industry'. Especially in less favoured regions, many persons are employed in public or semi-public agencies the mission of which is to vitalise or revitalise regional economies that have slipped behind either their comparators or their previous performance. They have a perspective on the nature of their task, the problems they must face and the useful as well as useless policy instruments implemented in their governance areas or those of equivalent agencies elsewhere.

We will engage in a brief 'sensemaking' exercise to illustrate the paradigms, frames and schemas that require adjustment for such bodies and their enterprise and innovation support teams to be able to move ahead in synchronisation with the changed economic trajectories. Moreover, attention will be paid to instruments deployed for so doing. In exemplifying this, the focus will be on building *Regional Innovation Systems*, a now popular regional policy instrument, having been subject of research in at least fifty empirical studies (see Cooke, Heidenreich & Braczyk, 2003) and policy in a range of regional and inter-regional settings (e.g. Northern Ireland; Cooke, Roper & Wylie, 2002;2003, and the more than 100 EU regions listed in Lanadabaso, 1997; Øresund is the first international regional innovation system to be built, Törnqvist, 2002).

Finally, in Section 3, we will briefly explore five ‘boundary-crossing’ institutions and instruments that have been mobilised in diverse settings to aid integration of distinct communities of practice or ‘epistemic communities’ for economic development (Brown & Duguid, 2001; Haas, 1992) . These are:

- Regional Science Councils
- ‘Lighthouse’ Projects
- Intermediary Technology Institutes
- Innovation Accelerator-Incubators
- Arm’s length Venture Capital

Evidence suggests that they are relatively easily brought into interface contact in Regional Innovation Systems (RIS) that were established already in the ‘Industrial Age’ but require significant re-adjustment faced with Knowledge Economies even in such accomplished settings. In less favoured regions Knowledge Economy requirements create great strains on often public-led economic restructuring agencies, and some evidence of such difficulties is presented. It seems a major task, familiar to those operating in Developing Countries, that arises because academics and consultants, particularly, offer a beguiling strategy to be aimed at but few or no mechanisms by means of which policy actions that will reliably terminate in strategic goals achievement or ‘implementation of the vision’ can be formulated (UNIDO, 2002).

Finally, conclusions on the implications of Knowledge Economies for regional development agencies and strategies will be drawn.

1. The Knowledge Economy and ‘Knowledge Economies’

It is increasingly widely-accepted that we have entered the ‘Knowledge Economy’ and that this is different from the ‘Information Age’ because it refers to specific assets that consist in knowledge ‘how to’, ‘who to’ and ‘what to’ deploy to create value. It is an active economic practice rather than a passive information space, upon which it nevertheless depends, but in ways that express value through the scarcity of 'knowledgeable' expertise. Manuel Castells (1996) speaks of the knowledge economy being one in which productivity derives from the interaction of knowledge upon knowledge rather than upon raw materials. Nonetheless, it is wrong to dismiss traditional or 'old economy' economic activity as not belonging to the knowledge economy, as for example the OECD does. Rather we can also usefully speak of 'pure' and 'applied' knowledge economy activity; the first captured in genomics, software and, for example, 'futures' or derivatives trading in financial services, or conceptual art. The second is in many other sectors that conduct or use R&D even though it is applied to, for example, food production, fashion design, or fire insurance.

A key reason for believing that a significant shift has occurred taking us into a Knowledge Economy is that data suggest this to be true. Thus the book value of intangible assets compared to raw materials has shifted from 20:80 in the 1950s to 70:30 in the 1990s. It is now routine (and controversial) for firms to include the value of such intangibles as 'Goodwill' in their balance sheets (Dunning, 2000). A dot.com business had in early 2003 to reduce its balance sheet asset value by $30 billion because of the downturn in the value of the sector's 'Goodwill' compared to during the boom. Goodwill in those times was associated fundamentally with being seen as inhabiting a knowledge-intensive sector of the economy. We have seen many other firms in the 'knowledge' or 'new economy' sectors having to reduce their book value because of the over-valuation of such intangibles as perceived from the bottom of the growth curve as distinct from the top.

It is important to say straightforwardly that the deployment of knowledge in economic affairs is not a new thing. Making a fire is clearly a knowledgeable and, in the deep past, powerful, knowledge-based skill, as the Prometheus myth testifies. Hunting, farming, smelting copper, bronze and iron, later steel are knowledge-based activities. In turn these knowledges became the basis for science and its application in early industrial technology. From coal-mining grew coal tar production, the origin of the German dyestuffs industry whose aniline products led to branching into pharmacology, the (re-) discovery by the Bayer corporation of Aspirin and the birth of modern pharmaceuticals. This industry is now shifting from its synthetic chemistry origins into post-genomics and other variants of molecular biology and the science-based biotechnologies of the future.

In the process, this gives us a clue about the possible core differences between the contemporary and future knowledge economy compared to the era when Aspirin was first marketed, which is often referred to as the ‘Industrial Age’. In the Industrial Age, industry was centrally concerned with the recovery from nature of raw materials that could be processed into usable products like textiles, steel, ships, drugs and so on. To a large extent the sources for these natural resources determined the location of industrial activity. Thus Bayer is located at Leverkusen, across the Rhine from Cologne with its established university training and research skills, and a short train ride from the Ruhr coalfields. The location was thus good for high-skilled labour recruitment and an ideal transhipment point for raw material inputs (coal tar and other coal-derived chemicals) and finished product outputs up or down the Rhine and via the extensive railway network centred in the Ruhr-Rhine region.

To stay with Aspirin for a while, when Bayer chemists first processed it industrially, it was thought to be best marketed as a fever treatment, not a painkiller since it had shown in trials some success in that regard. It was only by chance that patients later reported its effectiveness as a painkiller and this lead to refinement of its target market. Surprisingly, it was as late as the 1990s that its powers as a supplement with positive effects upon blood flow and value as a therapeutic in cardiac health were discovered. Even more recently certain negative effects upon young people have also been discovered for the tiny minority prone to Rea’s disease, and its properties as a wonder drug have been slightly undermined. The reason for this diversion into the evolution of Aspirin and its uses is to emphasise the ‘chance discovery’ element that normally accompanied scientific and technological progress in the Industrial Age. Even though Bayer and other German chemicals companies pioneered the concept of the in-house central R&D laboratory, an idea taken up highly effectively by American corporations like Dupont, AT&T and General Electric, research was and remains expensive and somewhat ‘hit-and-miss’ under the chance discovery method. In 2003, it has been discovered that Aspirin is now thought to offer protection against a number of types of cancer.

Knowledge Economy Index Methodology

Before proceeding to the data and a discussion of their interpretation, drawing considerably on Table 1, which contrasts the top and bottom twenty EU Knowledge Economies, some words are necessary to explain the methodology. As hinted already, it is simple and fundamentally non-technical, based on the OECD (1999) definition as ‘high tech manufacturing plus knowledge-intensive services' share of regional employment'. The source data are found in the European Commission (2001) *Eurostat* report entitled *Regions: Statistical Yearbook 2001.* The accompanying CD-ROM provides the source data at NUTS 2 level This is provided for numerous regional indicators, but of interest here are the source data for 'high technology manufacturing' and knowledge-intensive services' employment shares of total employment by member state for the EU 15 as of 1998, the year for which the data are available. The sectors included are NACE Rev. 1 24 and 29 to 35. Knowledge-intensive Services are NACE Rev. 1 61, 62, 64-67, 70-74, 80, 85 and 92. These data were added for each NUTS region for which they existed. In the case of Greece, 'high tech manufacturing' was only provided at NUTS 3 level, the next one up in scale. So NUTS 2 level estimates were made based on NUTS 3 entries and added to the NUTS 2 level data for knowledge-intensive services (which are provided at NUTS 2 level). A comparable exercise was performed for the Algarve (Portugal) and Estremadura (Spain) regions, based on means taken from comparison with neighbouring regions. This completed the continental EU regional picture. No data were available for the insular EU (e.g. Madeira, Guadeloupe). Totals for each region (NUTS 2) were then normalised to an EU Mean. This was a sample mean taken from summing the upper and lower twenty scores and calculating the mean accordingly. Finally the scores were normalised to an index where the mean was equal to 100 and each score was transformed into a percentage >100 or <100 that is represented in the tables that follow. In the report we use the sample mean approach to analyse the data because the data are more 'stretched' between end points in the distribution. The downside is that the mean is inflated by about 6 percentage points.

Moving to the EU scale, one difference from the OECD definition is that it includes automotive engineering in the high technology category whereas OECD does not.

High	Index	Low	Index
Stockholm (S)	169.5	Notio Aigaio (Gr)	36.7
London Inn (UK)	166.8	Sterea Ellada (Gr)	38.4
West Sweden (S)	155.2	Peloponnissos (Gr)	43.9
Surrey & Sussex (UK)	153.6	Anat-Maked-Thraki (Gr)	46.4
Brabant Wallonie (BE)	152.4	Norte (P)	50.2
London O. (UK)	151.6	Dytiki Ellada (Gr)	50.9
Piemonte (I)	150.7	Kriti (Gr)	50.9
Ostra Mellan Sweden (S)	150.0	Centro (P)	51.1

Berkshire-Oxford (UK)	149.0	Dytiki Makedonia (Gr)	51.6
Bedford-Hertford (UK)	148.9	Alentejo (P)	53.8
Uusima (Helsinki) (Fi)	148.8	Ionia Nissia (Gr)	53.9
Ovre Norrland (S)	148.4	Algarve (P)	54.7
South Sweden (S)	148.1	Thessalia (Gr)	55.2
Mellan Norrland (S)	147.6	Ipeiros (Gr)	59.6
Brussels (BE)	145.0	Castilla la Mancha (ES)	60.6
Paris (F)	144.9	Voreio Aigaio (Gr)	62.3
Norra Mellan (S)	143.3	Kentriki Makedonia (Gr)	62.7
Hampshire (UK)	141.6	Murcia (ES)	64.1
Stuttgart (G)	141.1	Estremadura(ES)	64.9
West Midlands (UK)	140.1	Balearics (ES)	65.3
EU		100.0	

Table 1. Knowledge Economies Index Numbers, European Union, 1998

Examination of Table 4 (full results in Cooke & De Laurentis, 2002) shows ‘knowledge economy’ accomplishment associated with:

- highly urbanised financial, media and technology capital cities (Stockholm, London, Helsinki, Brussels and Paris),
- their metropolitan fringes (Surrey-Sussex, Brabant-Wallonie, Berkshire-Oxford, Bedford-Hertford etc.),
- industrial and research regions and cities (Piemonte- [Turin], W. Sweden- [Gothenburg], Ostra Mellan-[Linköping], Ovre Norrland-{Umea-Lulea], S.Sweden- [Malmö-Lund], Stuttgart, and West Midlands). In many of these, such as Turin (FIAT), Gothenburg (Volvo), Linköping (Saab), W. Midlands (Rover, Peugeot) and Stuttgart (Mercedes, Porsche) the automotive industry has some influence.

However, even in Stuttgart where ‘high tech manufacturing’ provides 20.4% of the total workforce, ‘knowledge-intensive services’ are greater, giving a total for both of 48.8%. In Piemonte, the former is 13.9% and the total 52.2%, while in the Swedish automotive cases the ratios are some 10-11% to 42-44%. Hence, services always account for a greater part of the overall score than industry. It is also the case that the last-named group of regional cities are known for having close research-industry links, usually involving university-industry missions, and good interaction with government industry agencies, in line with the so-called ‘Triple Helix’ concept of Etkowitz & Leydesdorff (1997).

Regarding the locales with low 'knowledge economy' indicators - in spite of their frequent scenic and touristic assets, which, however it must be noted are not such great GDP earners as those economic activities identified with 'knowledge economies', hence their frequent Structural Funds designations – they fall into three categories as well:

- remote island regions like Notio Aigaio (Dodecanese and Cyclades), Kriti (Crete), Voreio Aigaio (Lesvos/Samos), Balearics and Ionia Nissia (Ionian Islands) near international frontiers thus a substantial distance away from member state capital cities
- agricultural regions with urban, industrial main cities focused on traditional production related to exploitation of primary raw materials, such as Sterea Ellada (Corinth-Thebes), Anatolia-Makedonia-Thraki (Komotini - tobacco), Dytiki (Western) Macedonia (Kozani – leather, furs), Thessaly, Ipeiros, Central Macedonia (Thessaloniki – textiles), Norte (Braga – textiles, leather), Centro (Aveiro-Coimbra – ceramics, metallurgy), Alentejo (cork), Castilla y la Mancha (food) and Estremadura (food)
- tourism and agricultural regions on the mainland such as Peloponnese, Alentejo, Algarve, Thessaly, Epirus and Murcia

Thus the low 'knowledge economy' regions are universally engaged in sectors with lower productivity, innovation and gross value added, hence GDP. They are squarely in the 'Applied' Knowledge Economy category to the extent science or technology play a part in economic activity, and knowledge-intensive services like software, research financial services and media are largely absent. Nevertheless, such regions frequently possess universities that may act as focal points for knowledge economy development. Moreover, there are arguments that could favour decentralisation or development of new research centres in food, oceanography, agricultural bioscience, textiles, design and tourism that would assist these economies to become more knowledge-intensive, albeit in traditional sectors. Interestingly, where a policy of establishing national research centres in a remote island setting was implemented with a view to evolving a 'local Silicon Valley' effect, namely Crete, this has had little evident effect in raising that island much above Thraki, near the Turkish frontier, in terms of its 'knowledge economy' index number (Crete 50.9, Thraki 46.4).

To complete this data analysis section, it is worth devoting a little space to interpretation of results for the next 20 regions beneath or above the ones just described. This is because, on the one hand, the second tier of accomplished 'knowledge economies' may aspire reasonably in some cases to displacing some of those above them, while, on the other, those more accomplished than the least high scorers may display characteristics their 'inferiors' might seek to emulate adapt or at least learn from. Table 2 displays these two 'middling' regional groupings. Key things to notice here are the much greater bunching of scores among quite distinctive regions and cities as the mean is approached a step more closely. Moreover, in the EU comparative context, some cities or regions that might be thought of as less favoured, and indeed to have warranted that designation by receipt of Structural Funds Objective 1 status, nevertheless score relatively highly on the 'knowledge economy' index. An obvious case is the UK's Merseyside. Reflection on that positioning draws attention to the national factor at work to some extent, as many UK areas score relatively highly because of the greater 'post-industrial' character of most cities and indeed, much of the economy, compared to many other EU member-states. Nevertheless, Merseyside possesses long-established financial services, pharmaceuticals and (automotive) engineering activities that raise it rather higher than might be expected, compared particularly with its near-neighbour Greater Manchester. However, it is worth noting that the percentage point difference between the two is only approximately 6.

Region	Higher Index	Region	Lower Index
Merseyside (UK)	**138.5**	**Galicia (ES)**	**66.80**
Essex (UK)	**137.9**	**La Rioja (ES)**	**66.83**
Darmstadt (G)	**137.7**	**Asturias (ES)**	**66.85**
South West Scotland	**137.5**	**Valencia (ES)**	**71.9**
Karlsruhe (G)	**137.4**	**Andalucia (ES)**	**75.3**
Utrecht (NL)	**137.2**	**Puglia (I)**	**77.9**
Denmark	**137.1**	**Castilla y Leon (ES)**	**78.6**
Vlaams Brabant (BE)	**136.8**	**Umbria (I)**	**80.5**
Vienna (A)	**136.1**	**Trentino-Alt Ad. (I)**	**82.6**
East Scotland	**135.9**	**Basilicata (I)**	**82.7**
Smaland (S)	**135.7**	**Sardinia (I)**	**82.8**
Gloucs-Wilts-N. Somerset (UK)	**134.9**	**Burgenland (A)**	**83.3**
Berlin (G)	**134.6**	**Abruzzo (I)**	**83.4**
Cheshire (UK)	**134.4**	**Styria (A)**	**83.6**
Noord-Holland (NL)	**134.3**	**Marche (I)**	**83.7**
Hamburg (G)	**134.2**	**Lisbon (P)**	**83.9**
Oberbayern (G)	**133.1**	**Mecklenburg (G)**	**84.9**
Hereford-Worcs-Wr'ckshire (UK)	**132.9**	**Sicily (I)**	**85.0**
Northumb'lnd-Tyne & Wear (UK)	**132.8**	**Cantabria (ES)**	**85.7**
Greater Manchester	**132.4**	**Tuscany (I)**	**85.9**

Table 2. Mid-Upper and Lower EU Knowledge Economy Index Numbers, 1998

The entrants in the higher index part of Table 2 are mostly more urban and industrial, but with an emphasis on mid-size entrepreneurship in the non-metropolitan locations. Thus places like Småland in Sweden are in this category, as is Karlsruhe in Germany, Essex (UK) Gloucestershire-Wiltshire-N. Somerset in UK, Cheshire (UK) and Hereford-Worcester-Warwickshire (UK). Alternatively, some large cities, some restructuring, others quite buoyant are to be found here. Thus Liverpool, Manchester, Newcastle, Glasgow, Edinburgh (all UK), Amsterdam and Utrecht (NL), Vienna (A), Berlin, Hamburg and Munich (G) are present. This signifies the importance, already drawn attention to, of cities as repositories of 'knowledge economy' activities.

By contrast, relatively few major cities are found in the part of Table 2 referring to mid-lower index number regions. The obvious exception is Lisbon, possibly Valencia, Cantabria (Santander), Palermo (Sicily) and Seville (Andalucia). But these are scarcely in the scale or tradition in manufacturing or services added value of even the lesser cities just discussed. They are mostly serving regional or in limited ways national markets rather than major export markets, for example. Elsewhere, the regions in this list are often pleasant, touristically attractive and well developed infrastructurally to absorb large numbers of visitors. Their cultural and gastronomic appeal is often internationally respected. Here are found such regions as Tuscany, Sicily, Marche, Sardinia, Trentino-Alto Adige, Umbria and Puglia in Italy. Also found in this segment are Galicia, La Rioja, Andalucia, Castilla y Leon and Cantabria in Spain – both sets of regions containing mountainous and coastal touristic areas and abundant facilities. Without labouring the obvious point at length, these regions are largely smaller-scale light industry, including classic 'industrial districts', high quality agricultural and viticultural, and touristic regions, many attracting more specialised and culturally oriented as well as mass tourism.

Finally, if we take 40% as a cut-off point between Knowledge Economies and non-Knowledge Economies, based on the raw scores (shares of regional employment accounted for by high technology manufacturing plus knowledge-intensive services) a flavour of the results are as shown in Table 3. The definition of the Knowledge Economy deployed here is 'an economy in which more than 40% of employees are employed in high technology manufacturing and knowledge-intensive services'. Some 43% of EU regions score 40% or more and, as can be seen from the selection of regions in Table 3 scoring above and below the 40% line, such a demarcation produces rational results. 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.

Region	>40% Knowledge Economy	Region	<40% Knowledge Economy
Stockholm	58.65	Gelderland	39.99
London	57.73	Northern Ireland	37.31
Piemonte	52.17	Sachsen	35.97
Helsinki	51.51	Upper Austria	34.28
Île de France	50.17	Attiki	33.79
Stuttgart	48.84	Navarra	32.06
S.W. Scotland	47.59	Auvergne	31.82
Utrecht	47.49	Calabria	31.29
Rhône-Alpes	42.22	Alentejo	18.63
S. & E. Ireland	40.18	Notio Aigiao	12.70

Table 4: Selected Regions From Knowledge Economy Index, 1998 Data

Source: CEC (2001); Cooke & De Laurentis (2002)

To conclude this section of the paper, three things may be said with confidence regarding the tasks of development agencies faced with the Knowledge Economy. First, the strong Knowledge Economies may rely more or less comfortably on market forces to facilitate their adjustment. Contrariwise, the lowest scoring regions must find ways to integrate their tourism and agriculture directly into the Knowledge Economy. Finally those in the areas relatively close to the 40% cut-off have the difficult task of adjusting trajectories set on a more 'Industrial Age' curve, even including a re-industrialisation curve involving attraction of high technology production through Foreign Direct Investment (e.g. S.W. Scotland, Rhône-Alpes and S.E. Ireland, N. Ireland, Sachsen, Upper Austria and Navarra) towards Knowledge Economies. It is these kinds of regional economy that much of the rest of this paper focuses upon.

2. Sensemaking Regional Innovation Systems

In this section we will first distinguish between two types of Regional Innovation System that emerged from research such as that reported in Braczyk, Cooke & Heidenreich (1998); Cooke, Boekholt & Tödtling (2000) and Cooke, Heidenreich & Braczyk (2003). These are, respectively, Entrepreneurial, and Institutional Regional Innovation Systems (ERIS & IRIS).

A *Regional Innovation System* consists of two sub-systems. The first is the 'Knowledge Generation' sub-system. The second is the 'Knowledge Exploitation' sub-system. Most regions, and many nations, have poor linkage between the two sub-systems. Where nations or regions have overcome this barrier, it is either through successful working of market mechanisms, set in an appropriate regulatory environment, classically in the USA. Or market failure is overcome by the establishment of state entities that directly or indirectly seek to straddle the 'exploration' to 'exploitation' divide. Regional development agencies have often embarked on the second of these to integrate necessary knowledge flows, since the first option is emergent but not yet mature. Indeed, by comparison with leading regional innovation systems in the USA such as that of Greater Boston and Massachusetts, or San Diego and Silicon Valley in southern and northern California, most European regions are constrained to public intervention if regional innovation is to function systemically. Of course, a majority probably do not have meaningful Regional Innovation Systems, something that contributes significantly to the much-touted 'innovation gap' identified by the EU and others between Europe and the USA.

The key mechanisms facilitating the flow of knowledge, whether intra-regional, inter-regional or international, are knowledge itself, resources (particularly finance), and human capital. In strong market systems, venture capitalists that are proactive in seeking and assessing knowledge competences in laboratories are crucial links across the exploration/exploitation boundary (Kenney, 2000). They are increasingly highly attuned to the nuances associated with specific, advanced fields of research, the 'star' scientists associated with leading edge research, and risk assessment associated with its commercialisation. In systems such as Silicon Valley some scientists and engineers are highly attuned to stock markets, prospects for venture funding and initial public offerings (IPO). It is clear to see that the systemic nature of the likely interaction between scientific research, i.e.'knowledge generation' (itself involving exploration and *examination* knowledge, the latter involving trialling and testing competences), and innovation or 'knowledge exploitation' is massively assisted by these 'boundary crossing' competences. To that must be added the prevalence of 'academic entrepreneurs' managing a spinout firm while keeping an academic post in a nearby university, and receiving business management support from venture capital. These and their staff convey knowledge of distinctive kinds across boundaries too, and the micro-system of the firm operates as a seamless web. But added value comes from the fact that venture capital invests in portfolios of proximate and non-proximate firms among which, at the inter-firm and inter-research centre levels, comparable knowledge transfer occurs both formally and informally. It is this network form embedded in market transactions and some 'untraded interdependencies' that typifies the 'open systems architecture' of the ERIS or Entrepreneurial Regional Innovation System (Dosi, 1988; Best, 2001)

Where Entrepreneurial Regional Innovation Systems are underdeveloped, perforce ambitious regional administrations develop institutions to facilitate comparable effects through establishing 'boundary crossing' institutions that may forge an 'Institutional Regional Innovation System'. The most fully researched of these is Baden-Württemberg in Germany, for which detail can be found in Herrigel (1996) and Cooke & Morgan (1998). To be brief, the key 'boundary crossing' institutions are, for larger firms, the Fraunhofer Institutes, of which there are fourteen conducting applied research, and for smaller firms the Steinbeis Foundation, now numbering some three hundred transfer centres based in Higher Education Institutes and Innovation Centres. Fraunhofers conduct publicly subsidised, industry-funded research to solve technological or managerial problems, assess technologies and conduct foresight activities. They bridge the basic research function of the fourteen Max Planck Institutes and the ten universities across to the commercial application requirement from firms. Steinbeis provides a similar subsidised consultancy function for SMEs. Neither engages in spinout activity, which again is seen as an Innovation Centre or incubator function in Science Parks located close to universities. Assessment of this version of an IRIS is that it works well where technology and innovation tends to be path dependent rather than disruptive (the latter being more typical of the ERIS set-up), where institutions have grown incrementally to meet needs in an evolving but well-understood sectoral innovation system (in this case automotive engineering), and where specialised in-house expertise familiar with technology application work is in place.

Thus, at key points where epistemic communities like 'academic engineers', 'civil servants' and 'business managers' must communicate on policy-related matters there are 'boundary crossing' *buffers* like Fraunhofer Institutes, Business Associations and Science Park Incubator

Centres that interpret among distinct communities of practice thus enabling (international) regional knowledge flow from *exploration* through *examination* to *exploitation* knowledge categories. But this sophisticated externalised 'knowledge management' system is itself an 'epistemic community' writ large since it has, despite its professional divergences, an industrial convergence around automotive engineering, given it is a regional economy that is inordinately dependent on its star auto firms like Mercedes, Porsche and Audi, not to mention major suppliers like Bosch, ZF and ITT (Cooke & Morgan, 1998):

> "An epistemic community is a network of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy relevant knowledge within that domain or issue-area" (Haas 1992, 3)....."Presented with incomplete or ambiguous evidence, members of an epistemic community would draw similar interpretations and make similar policy conclusions. If consulted or placed in a policymaking position, they would offer similar advice.... Unlike an interest group, confronted with anomalous data, they would retract their advice or suspend judgment" (Haas 1990, 55).

This has happened on many occasions in the past when efforts have been made to shift trajectory into new industries like multimedia, solar energy, sensors and biotechnology. Somehow, when one examines change in the Baden-Württemberg regional economy it tends to show the emergence of more knowledge-intensive software design and engineering, greater engineering consultancy and other knowledge-intensive business services activities closely related to automotive engineering as the shifts in question. Thus this *land* finds it hard to elaborate industries outside the core 'epistemic community' despite, or perhaps because of, its highly refined IRIS.

If we move to a different, less accomplished, but argued to be 'learning region' (Cooke & Morgan, 1998), this time Wales we find a rather poignant story in which 'boundary crossing' was orchestrated largely by a single, hierarchical IRIS, namely the Welsh Development Agency. While the private sector was leading the innovation effort, especially in the shape of inward investors from Japan, Wales was the only UK region in which manufacturing employment continued to grow and a good innovation profile was registered (see Cooke et al., 2000). But during 1998-2002, 44,000 manufacturing jobs disappeared as these innovators shifted production to Central & Eastern Europe and elsewhere while other firms went under. Although public agencies had worked closely with such firms – even assisting in the building of supply-chain clusters in electronic and automotive engineering – they seem to have learned little. Now, even an innovative public venture capital entity, established to compensate for market failure, is inducing 'rent-seeking' from interested equity-hunting innovators by requiring them to raise half the required amount from grant-aid first.

It is not difficult to engage in 'sensemaking' regarding the WDA's efforts to re-align the top-down regional innovation system that emerged with heightened FDI activity in the 1990s. That 'system' (for it had some but not all such features) involved the import of *exploration* and *examination* knowledge from abroad with FDI, embedding FDI by assisting construction of regional supply chains, supporting SMEs and their knowledge *exploitation* capabilities, linking in skills training to produce technicians and semi-skilled engineering workers and, encouraging investment in related R&D directly by FDI firms or indirectly to universities by earmarking Centres of Expertise. This began to bear fruit up to around 1998 when FDI dried up, and worse, began to move offshore.

The new 'Entrepreneurship Innovation' approach has four main components that can be viewed as potentially systemic. These are:

- An Entrepreneurship Action Plan
- Finance Wales, a public-private Venture Capital and Business Loans fund
- A Knowledge Exploitation Fund
- Technium, an incubator building programme

Apart from private co-funding for the Venture Capital fund, everything else is public, a sign of 'market failure' in these respects, precisely the reason why IRIS arrangements are necessary.

Assessments of performance regarding initiatives such as the Entrepreneurship Action Plan (EAP), Knowledge Exploitation Fund (KEF) and Finance Wales (FW) are seldom published but Shipton (1993) showed that for the financial year 2001/02, in return for an average £80 million per year expenditure in its first three years, the EAP was set a target of providing support to 4,600 new business ventures, but in fact only aided 1,800 - a deficit of 2,800. For 2002/3 EAP was set a goal of supporting 6,300 start-up businesses and 4,000 start-ups were assisted by the WDA from April 2002. Part of this expenditure is on *entrepreneurship* modules in colleges. A report on KEF's own website shows that despite budgets of well over £20 million per year being spent only 5% more entrepreneurship modules were being taught in universities and other higher education institutes, although 25% more were taught in further education colleges. But 75% of the latter had no or few KTO mechanisms, while the statistic for universities was 25%. It can be concluded that there is a significant disconnect in this particular part of the entrepreneurship-driven renewal of the regional innovation system in Wales. Finance Wales, a vehicle designed to supply venture capital to innovative SMEs and start-up businesses because of a perceived market failure in private provision registers such disconnects in the far lower than targeted number of businesses coming forward in quest of equity investment. Accordingly, public venture capitalists are redeployed on to firefighting co-funding grant packages. Further administrative expediency and risk aversion has resulted in equity now being tied to accessing Regional Selective Assistance, thus incentivising entrepreneurs to becoming 'grant junkies' rather than weaning them off grant-dependence as modern investment theory advocates.

These may be teething problems, but they betray an absence of flexibility on the part of large public bureacracies and their communities of practice. Thus KEF is managed by the Skills and Learning agency (ELWa), and even though the organisation in question also manages the funding of Wales' universities, it is the community colleges to whom most resources are directed, for trivial training modules to and instrumentation access by SMEs. In March 2003, it was revealed that the CEO was only devoting one day a week to his university remit, that ELWa was to be split in two, with the university remit to be independently managed, and responsibility for KEF to be transferred to the Welsh Development Agency. However, while it may be preferable to have these key IRIS elements managed under one roof, it should be remembered that ambitions have been unfulfilled under WDA guidance in the three other spheres.

It is clear that this complex policy area is infused with boundary crossing problems that cannot be solved within public bureaucracy alone. There is a clear danger of 'goal displacement' (Selznick, 1949) of the kind exemplified by Finance Wales. Moreover, in the same way industry is legally bound to seek profits rather than donate gifts, and universities find profit-making activity hard to accommodate, so governments are ontologically challenged by the idea of financial risk, especially given the widespread presence of an 'audit culture' (Power, 1997). Yet innovation systems policies are closely intertwined with financial risk, whether arising from empty incubators, failed loans, aids to subsequently bankrupt businesses or lost venture capital investments, to name a few. Auditing emphasises a 'tick box' mentality and public incentive systems reward expenditure of resources but not losses arising from failures associated with such investment.

3. Regional Innovation System Boundary Crossing Instruments

We have seen that constructing Regional Innovation System nodes that interact among epistemic communities with different codes of ethics, such as those supposed to interlock according to the 'central dogma' of Triple Helix thinking, is difficult if directly orchestrated by government. Yet, in situations of market failure, such desirable policy action lines must be animated by the public sector unless generous trust or foundation resources can be assembled (as happened in Austin, Texas according to Henton et al., 1997). So, to make concrete, implementable proposals based on actual instances of establishing boundary crossing institutions, the following five cases can be offered. The first concerns the Knowledge Economy issue of science engaging with economic policy at regional level, a situation where, in England, regional development agencies have recently been deemed 'too immature' to foster innovation by themselves (Davis, 2003). If generically true, this means serious problems for the broader EU aspiration to raise innovativeness to US and Japanese levels, but a solution lies in establishing buffer institutions such as the following.

Regional Science Councils

Science strategy is far more basic than applied science supporting and is something that has begun to develop in the UK since about 2001. The Scottish Science Strategy was the first and targets e-science, bioscience and medical science as described in Cooke (2002b). It was commissioned by the Scottish Parliament, advised by the parliament's Science Policy Unit and consistent with economic development strategy which evolved from the initiative of Scottish Enterprise, the regional development agency, to embark upon a cluster development strategy that included facilitating cluster development in, amongst other fields, ICT and biotechnology. The strategy identified Scotland's R&D spend from public sources at about $1.2 billion and identified an above average success in accessing UK research funds. It seeks to augment these by re-allocations from within the Parliamentary budget and encouraging integration of research strategies among different research laboratories that the Parliament funds.

This course has also been followed, despite the absence of a parliament, by the North West region of England. In the aftermath of the debate about the location of the UK's new Diamond Synchrotron (important for Bioimaging) which went to Oxford in the heart of southern England's biotechnology belt, the North West used $40 million of compensation funding to upgrade its nuclear-age synchrotron, build a National Biomanufacturing Centre to conduct and train for biomanufacturing, develop collaborative bioscience projects between Liverpool and Manchester universities, and establish a Science Council. The Science Council reported in summer 2002, recommending special efforts be made to augment basic research funding in six areas, including biosciences, aeronautics, chemicals and textiles. This Science Strategy also links closely with the regional development strategy of North West England, building upon piecemeal efforts to establish bioscience clusters in Liverpool and Manchester. Because of the link to the regional development agency, a bid for the UK Biobank was able to be mounted in competition with other regions. The $70 million Biobank facility, is a ‘hub’ with regional linkages to store and make available for research and exploitation the genetic information from DNA samples and the medical records of 500,000 volunteers, aged 45-69 It is funded by the Medical Research Council, the Wellcome Trust and the UK Department of Health. A second English Regional Science & Industry Council was established in North East England in 2002.

In this way, according to key scientific advice given to the UK Office of Science and Technology and to the UK second chamber Science & Technology committee investigation into plans for a $150 million Higher Education Innovation Fund to be managed by regional development agencies, there is a perceived low trust relationship that would be moderated by Regional Science Councils. In the North West, its Regional Science Council consists of university vice chancellors, business leaders and scientists from industry and other public bodies. Noticeable is the fact that, public research labs apart, government representation is minimal, but also that science and industry are well represented, reflecting a presumably stronger trust relationship. Though this advice may not carry enough weight to change government policy, it is indicative of a fear that ‘goal displacement’ may devour these special resources, as exemplified in the following remark from committee witness Professor Sir Gareth Roberts:

> ‘RDAs were set up in 1999 to regenerate the regions and to build infrastructure..... Science was not mentioned in the RDAs three years ago. Universities are now very big businesses (sic) that know how to manage large research budgets. RDAs don’t have that experience...There is a feeling that the RDAs in England are not mature enough to distribute the money. The North West science council has a full appreciation of what’s required. The RDA is not fully equipped to do the role government hopes it will in the fullness of time’ (Davis, 2003).

As a growing phenomenon in the Knowledge Economy, implicit in which is the building of Regional Innovation Systems, regional science councils may find themselves more actively involved in Regional Science Policy than the advisory role they have adopted hitherto.

'Lighthouse' Projects

North Jutland in Denmark has been at the forefront of mobile telephony infrastructure under the GSM standard, since the 1980s. Many of its sixty or so start-up businesses spinning out from the technical departments of Aalborg University established on the university Science Park and were then often targets for equity stakes or acquisition by the likes of Amstrad and Bosch and Siemens. 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. 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' (Brunn, 2002). This was part of their 'Digital Denmark' initiative 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: IT infrastructure; E-Science; E-Learning & Skills; and E-Administration. 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 in North Jutland, knowledge transfer bridges the university-industry divide with government animating socially useful innovation through a 'Lighthouse' project**.** 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. Thus there are 'Lighthouse' projects on wireless services for delivery of healthcare, administration, local government services, and 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.

Intermediary Technology Institutes

Scotland is rebuilding its Regional Innovation System in recognition of the unsustainability of an FDI strategy when cheap locations abound elsewhere. Earlier difficulty in inducing an indigenous ICT industry value chain led to founding of the Alba Centre, a facility aimed at attacking the upper reaches of the value chain by training and spinout in advanced software. With Alba as something of a prototype, new Intermediary Technology Institutes (ITI) are now planned for Bioscience, ICT and Energy exploitation and commercialisation. Thus Scottish Enterprise, the regional development agency has learned, not least from ICT-rich Taiwan, about the importance for commercialisation of innovation of an intermediary entity like Taiwan's Industrial Technology Research Institute (ITRI) founded in 1973. From the perspective of managing international knowledge flows 'catch-up' in Taiwan was dependent less on basic research quality from indigenous Higher Education Institutes, than on forging alliances with TNCs like IBM and Motorola, then transferring technological knowledge to receptive SMEs for commercialisation. Taiwan's current dominance in mobile PCs rests on the work of such public-private consortia that rushed product to world markets (Mathews & Cho, 2000).

Adapted to the Scottish context, where the prospects for commercialising original, as distinct from cloned, knowledge are higher than they were in Taiwan, yet the university originators are, as elsewhere, inexpert at generic, swift-growth spinout incubation, and the innovative, technology-intensive SME sector is rather thin, ITIs have a logic to them, given the knowledge transfer and translation imperatives of turning exploration knowledge (basic research) into commercially exploited innovations. Thus basic research will be transferred into ITIs where a small staff will draw up contracts for such exploration knowledge to be examined with a view to exploitation by other, applied research academics under competitive tendering. Thereafter, results are to be sold, licensed, or stimulate business start-up activity. ITIs are thus aimed at meeting an important element of the challenge set by the Scottish Executive in its 'Smart, Successful Scotland' vision. This is the framework to which Scottish Enterprise works in the threefold strategy discussed above, linking the 'Global Connections', 'Growing Business' and 'Learning & Skills' action lines. As innovative Knowledge Transfer Organisations (KTOs) ITIs address the heart of the Knowledge Economy's boundary crossing conundrum between university research and industrial commercialisation.

Innovation Accelerator-Incubators

Oxfordshire *BioTechNet* bioincubator is, first, a ‘virtual’ incubator networking some 70 ‘mentors’ available to sell at or below cost (if subsidy is available) market services, and second, houses start-up tenants in hard accommodation owned by the bioincubator as an affiliate of the *Oxford Trust,* a charitable foundation, itself arising from the profitable activity of *Oxford Innovation* a successful scientific instrumentation business. To help set up the bioincubator a € 600,000 grant was won under a UK government (DTI) ‘Bio-challenge’ scheme in 1997 which assisted investment in incubator buildings. Although initial plans were for 1,000 square metres at a hospital site, land was found at Yamanuchi Research the Oxford home of Japan’s third largest pharmaceuticals business. Other shareholders invested nearly double the ‘Challenge’ funding and space was opened at the end of 2000. Oxford is one of the UK’s leading biotechnology ‘clusters’ with some fifty core biotechnology businesses (in the early 1990s only 3 or 4) and a further seventy support firms, located at various sites, including along the A34 ‘corridor’ to Abingdon.

In the main these are spin-outs from Oxford University Life Sciences and Medical School centres and departments. The incubator has 12 tenants, mostly single person companies moving towards second or third phase development. All are in biopharmaceuticals, ranging from reagents, to therapeutic sugars, gene therapy, cancer therapy, antibodies and bio-instrumentation. Most have UK government SMART innovation awards following exhaustion of which if Proof of Concept is validated business angel funding is intended to lead to product sales after some five years. One successful firm associated with the bioincubator is Oxford Glycosciences, one of the UK’s leading firms now in discussion on merger with either Cambridge Antibody Technologies, Celltech or Merlin Ventures as the UK’s biotechnology sector begins to consolidate. Thus BioTechNet is a private, not state-funded facility, though it has clearly benefited from state set-up funding. It lacks either the power or responsibility to seek a return for incubator services beyond rent. It provides market network access to private equity linking to, among others, Oxfordshire’s University Enterprise Network. Firms coming to the bioincubator are thoroughly vetted and validated by Oxford University’s *Isis* commercial office. Its strengths are its reputation, it’s image as a model to other incubators, its uniqueness in Oxfordshire and its strong university and mentoring links. It weaknesses are small size, with only three staff, dependence on private income and absence of a seed fund of its own. Future plans are to grow and offer 'accelerator' and 'follow-on' space. It is anticipated that the Yamanuchi site will soon host a Science Park which may meet the preceding aspirations.

Hadasit is an Israeli bioincubator, comparable to BioTechNet but even more of a 'one-stop shop'. Hadasit is fundamentally a for profit, incorporated company founded by the Hadasah Medical Organisation (HMO) , a women's health foundation that owns 100% of Hadasit's shares. In this sense it encompasses the *Isis* Technology Transfer Organisation (TTO) function, generating a royalty stream from its investment in spin-offs. In this way it offers a more comprehensive service than its UK comparator. Hadasit's aim is to increase the revenue base of the incubator. It's procedure involves Screening firm candidates, Agreement for pre-Proof of Concept funds followed by an IPR assessment. If it is selected, a Patent filing occurs conducted by Hadasit, leading to a final Prototype, preparation of a Business Plan and auditioning for Venture Capital.

Hadasit has made use of Israeli NOFAR funding of $120,000 for 12 months, funded 10% by industry which is given right of first refusal on technologies arising. Moreover the Horowitz Foundation gives $1 million per year to Hadasit. The Hadasit business approach emulates that of the Hapto Inc. model of Delaware, USA. This, for example, allowed a start-up created by Hadasit to in-license tissue-engineering platform technology and commercialise its IPR on behalf of HMO. A venture fund made a $1.5 million pre-seed investment to start the company and Hapto Inc co-operates in management in the HMO-owned Hadasit premises, concluding with a 'trade-sale' to a pharmaceuticals firm. As well as US partners, Hadasit links to incubation facilities in Singapore and Australia. It offers firms the widest range of services and benefits from growth in its equity stake in incubated start-ups. The incubator has firms specialising in thrombosis, cancer care, rheumatoid arthritis and hormone research.

These incubators perform vital functions in KTO activity, crossing boundaries between professional communities of practice and the larger Triple Helix buffer zones with relative ease. While BioTechNet operates amongst abundant private innovation support service markets and fits into the Regional Innovation System's 'knowledge value chain' between the KTO at Oxford University and the service providers in the market, Hadasit has to substitute for most of these market or university provided functions due to the absence of an ERIS. It is noticeable that while neither is a public body, nor are they market actors, relying on foundation funding and public grants, which suggests provision of this key 'bridging' function is not yet attractive to private innovation system service providers.

Arm's length Venture Capital

We saw earlier how having in-house public venture capital funds may leave them open to capture by goal displacement motivations. That is, if the designed service is not capable of proactively seeking clients and insufficient are forthcoming then, rather than close the service down another function is given to it thus saving jobs, resources and embarrassment. This has clearly happened in the case of Finance Wales. However, an alternative way of organising such a service is as practised through arm's length venture capital in Northern Ireland. Two venture capital firms 'in the market' were supported by public start-up investment from the predecessor of Invest Northern Ireland (INI) the province's regional development agency. An illustrative case of the advantage of a private venture capitalist presence in an otherwise 'market failure' regional setting for such services is the case of Belfast electronics firm Andor's difficulty with the financial regime in Northern Ireland. This arose from an approach to a bank that advocated acquiring a grant to warrant a loan. A fruitless process of grant-seeking led Andor ultimately to Crescent Capital, a venture capitalist (VC) who, for an equity-share solved Andor's grant and more general funding problem as it 'cut through an old boy network'. Others with whom Andor had positive experiences include Enterprise Equity (see below), and Dublin's Delta Partners. Thus this high-performance firm perceived a bureaucratic hierarchy crossing the public-private divide as constraining growth, something which would have been stifled without the presence of a private investor community.

Crescent Capital is a small (4-5 person) company but its experiences and practices are instructive of the manner in which the evolution of more systemic innovation might occur. Crescent was set up in 1995 initially with close links to Top Technology, the Hambro's Advanced Technology Trust group of venture funds. The firm manages a £14 million venture capital fund backed by £7 million from the EU Technology Venture Fund, pension funds, insurance companies and other UK investors. On the technology front, Crescent has close links to Belfast university incubator QUBIS and its start-ups when they reach the venture capital stage. Investments are also made in promising firms in traditional industries like sawmills and food businesses. The firm invests at between £250,000 and £750,000 and substantially larger investments are made in conjunction with other funds. Importantly, the managing director identified the activities of the firm as both investment in and management of firms, the latter occurring through placing a Crescent manager on the board of the firm being invested in with the role of active adviser.

A fairly regular partner of Crescent in funding syndicates is Enterprise Equity, established in 1987 as a private limited liability company employing 3-4 people and presently backed by the International Fund for Ireland. Funding is thus foreign and UK sourced for investment in Northern Ireland. Investments of up to £1.5 million range from early stage to development and acquisition, management buy-outs and buy-ins. Larger investments are made through syndicates and typical partners would include Crescent, 3i and AIB, the latter for bridging loan finance, often required as mezzanine funding when taking a firm public. While venture capital investment in Northern Ireland rose from £3 million in 1987 to £35 million in 2000, a funding gap exists for investments of between £100,000 and £500,000. It is considered relatively easy for University Challenge, a DTI/OST fund managed by Queen's and Ulster University research managers, or seedcorn funds like the Emerging Business Trust to mobilise up to £100,000 while venture capitalists are more comfortable with investments above £500,000, hence there are no Northern Ireland suppliers in-between. Partnering public bodies such as INI may become more common in tackling this problem if a permanent solution is to be found. But firms seeking investment need guidance towards venture capital sources rather than themselves having to learn about the complexities of public funding the hard way.

Despite the above implication of closer public-private partnership, an example of the difficulty with risk experienced by Northern Ireland's regional development agency INI and its predecessors is the following. In the early 1990s INI's predecessor made a loan of £3 million to an innovative start-up firm called BCO Technologies in Northern Ireland to increase its focus on optical devices for communications applications. The firm operated in a technology for which there was then an undeveloped market and the INI predecessor's fear was that the BCO start-up would collapse before repaying the loan. With a considerable struggle the loan was paid off with the assistance of Enterprise Equity. In 2003 Enterprise Equity offered INI a share in BCO, which because of its previous unhappy experience of risk, INI turned down. The U.S. analog chip supplier Analog Devices Inc. then purchased BCO, trading stock valued at $150 million, for the Belfast-based producer of integrated circuit wafers for micro-mechanical optical components. Enterprise Equity's share in BCO was valued at $13 million. The Analog Devices chief executive claimed his company's advanced micromachine technology, coupled with integrated analog and mixed-signal IC technology integrated on the same devices, 'uniquely positions ADI to become an important vendor to the optical network market.' He said BCO, employing 90 people at its factory in Belfast, is a leader in thick-film bonded wafers and silicon-on-insulator (SOI) technology, which would further enhance Analog Devices' position. When asked what INI would have done with its windfall had it invested, along with Enterprise Equity, in BCO a senior executive said there were no clear rules on what to do with profits to a public organisation (Cooke & Clifton, forthcoming).

Conclusions

This has been a contribution to understanding of the difficulties caused for Regional Innovation Systems by epistemic boundaries, of the kind that are central to the Knowledge Economy pressures that force engagement among historically incompatible communities of practice, notably the Triple Helix interlocutors identified as universities, industry and government by Etkowitz & Leydesdorff (1997) and recently asserted by Etkowitz (2003) to have cybernetic system guidance. The analysis began with an in-depth exploration of the nature and implications for regional science and innovation policy of the rise of the Knowledge Economy with its significantly uneven spatial effects. This showed three policy-relevant problems. First, strong Knowledge Economies may rely more or less comfortably on market forces to facilitate their adjustment. Second, the weakest regions must find ways to integrate their traditional assets directly into the Knowledge Economy. Finally those in the areas relatively close to the 40% cut-off have the difficult task of adjusting trajectories set on a more 'Industrial Age' curve given they may already have developed aspects of regional innovation strategy around now-disappearing FDI manufacturing, possibly in high technology sectors.

Attention then turned to the nature of Regional Innovation Systems in both strong and weak Knowledge Economy settings. Distinctions were made between Entrepreneurial and Institutional Innovation Systems which, unbeknown at the time by this author, are comparable to distinctions between entrepreneurial and institutionalised technological regimes made by Winter (1984) and Audretsch (1994). Where Entrepreneurial Regional Innovation Systems (ERIS) are underdeveloped regional development agencies develop institutions to facilitate comparable effects through establishing 'boundary crossing' institutions to forge government-initiated links towards an Institutional Regional Innovation System (IRIS). Boundary crossing is less problematic where government is absent, something clarified by later references to the inappropriateness of regional development agencies managing scientific innovation funding in

England. However, markets for innovation support services are often not at all well-developed away from metropolitan 'safe havens' so government initiation and animation of innovation support activities is often vital. What government does not, however, do well is dealing with risk and managing boundary crossing knowledge flows more generally. Science and industry seem better-equipped for that, perhaps because less rule-governed and flexible internally, albeit with external regulatory codes in their professional practice. This creates further problems but also opens doors to experimentation and solutions.

These were analysed in the final section. This focused on five 'boundary crossing' institutions for Regional Innovation System building. Each involved some kind of imtermediary outside the public sector. This ranged from the Regional Science Council managing interactions between universities and regional economic strategists, through 'Lighthouse' projects that facilitate market discovery by engaging users rather than producers of socially relevant technological innovations, thus bridging university, industry and society gaps by 'contextuating' innovation (Nowotny, Scott & Gibbons, 2001), to Intermediary Technology Institutes for bridging the knowledge exploration to exploitation gap which universities are generally perceived to be relatively ineffective at tackling, to Accelerator-Incubator facilities that cross numerous boundaries affecting the exploitation of new knowledge as commercially viable innovations in the market, and finally, arm's length venture capital that can handle risk in ways public investors often seem reluctant so to do. Thus by scanning and learning, administrations that are faced with daunting problems in innovation system building may overcome these by judicious adaptation of boundary crossing institutions that have been applied elsewhere (e.g. Scotland learning and adapting from Taiwan) or developing appropriate boundary crossing institutions from new. The key feature of all such boundary crossing institutions is that they should be outside direct public sector control, mainly because all involve some degree of risk-taking that public sector functionaries are by and large neither trained nor competent to perform.

References

Audretsch, D. (1994) Marktprozess und Innovation, W. Zapf & M. Dierkes (eds.) **Institutionenvergleich und Institutioendynamik**, Berlin, Wissenschaftzentrum Jahrbuch, 310-326

Best, M. (2001) **The New Competitive advantage**, Oxford, Oxford University Press

Braczyk, H, Cooke P. & Heidenreich, M. (1998) **Regional Innovation Systems**, London, UCL Press

Brown, J. Seely & Duguid, P. (2001) **The Social Life of Information**, Boston, Harvard Business School Press

Brunn, H. (2002) Mobilising a regional lighthouse: a study of the Digital North Denmark programme, presented to the *Digital North Denmark Research Seminar*, Aalborg, November 21-22

Cassidy, J. (2002) **dot.con**, London, Penguin

Castells, M. (1996) **The Rise of the Network Society**, Oxford, Blackwell

Cooke, P. (2002a) **Knowledge Economies**, London, Routledge

Cooke, P. (2002b) Towards regional science policy? The rationale from biosciences, Presented to Conference on *Rethinking Science Policy: Analytical Frameworks for Evidence-Based Policy*, Science Policy Research Unit, University of Sussex, March 21-23

Cooke, P. & Morgan, K. (1998) **The Associational Economy**, Oxford, Oxford University Press

Cooke, P, Boekholt, P. & Tödtling, F. (2000) **The Governance of Innovation in Europe**, London, Pinter

Cooke, P. & De Laurentis, C. (2002) The Index of Knowledge Economies in the European Union: Performance Rankings of Cities and Regions **Regional Industrial Research Report 41**, Cardiff, Centre for Advanced Studies

Cooke, P, Roper, S. & Wylie, P. (2002) **Developing a Regional Innovation Strategy for Northern Ireland**, Belfast Northern Ireland Economic Council

Cooke, P, Roper, S. & Wylie, P. (2003) 'The 'golden thread of innovation' and Northern Ireland's evolving regional innovation system, **Regional Studies**, 37, June

Cooke, P, Heidenreich, M. & Braczyk, H. (2003) **Regional Innovation Systems 2nd Edition**, London, Routledge

Cooke, P. & Clifton, N. (forthcoming) Funding Economic Development in Northern Ireland, ESRC Devolution & Constitutional Change Programme Report, Cardiff Centre for Advanced Studies

Davis, C. (2003) RDAs 'too immature' to foster innovation, **The Times Higher Education Supplement**, March 21, 6

Dosi, G. (1988) Sources, procedures and microeconomic effects of innovation, **Journal of Economic Literature**, 26, 1120-1171

Dunning, J. (ed.) (2000) **Regions, Globalisation & the Knowledge-Based Economy**, Oxford, Oxford University Press

Etkowitz, H. (2003) Research groups as 'quasi-firms': the invention of the entrepreneurial university, **Research Policy**, 32, 109-121

Etkowitz, H. & Leydesdorff, L. (eds.) (1997) **Universities and the Global Knowledge Economy**, London, Pinter

EU (2002) **Regions: Statistical Yearbook 2002**, Luxemburg, Commission of the European Communities

Henton, D, Melville, K. & Walesh, J. (1997) **Grassroots Leaders for a New Economy**, San Francisco, Jossey-Bass

Herrigel, G. (1996) **Industrial Constructions: the Sources of German Industrial Power**, Cambridge, Cambridge University Press

Fusaro, P. & Miller, R .(2002) **What Went Wrong at Enron**, Hoboken, John Wiley

Haas, P. (1990) **Saving the Mediterranean: the Politics of International Environmental Cooperation**, New York, Columbia University Press

Haas, P. (1992) Introduction: epistemic communities and international policy coordination, **International Organisation**, 46, 1-37

Kenney, M. (ed.) (2000) **Understanding Silicon Valley**, Stanford, Stanford University Press

Landabaso, M. (1997) The promotion of innovation in regional policy: proposals for a Regional Innovation Strategy, **Entrepreneurship & Regional Development**, 9, 1-24

Mathews, J. & Cho, S. (2000) **Tiger Technologies**, Cambridge, Cambridge University Press

Nowotny, H. et al. (2001) **Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty**, Cambridge, Polity

OECD (1999) **S&T Indicators: Benchmarking the Knowledge-Based Economy**, Paris, Organisation for Economic Cooperation & Development

Power, M. (1997) **The Audit Society: Rituals of Verification**, Oxford, Oxford University Press

Selznick, P. (1949) **TVA and the Grassroots**, Berkeley, University of California Press

Shipton, M. (2003) Targets missed in entrepreneurship plan, **Western Mail,** 16 January

Törnqvist, G. (2002) **Science at the Cutting Edge: the Future of the Øresund Region**, Copenhagen, Copenhagen Business School Press

UNIDO (2002) **Competing Through Innovation & Learning**, Vienna, United Nations Industrial Development Organisation

Winter, S. (1984) Schumpeterian competition in alternative technological regimes, **Journal of Economic Behaviour & Organisation**, 5, 287-320