From Technopoles to Regional Innovation Systems: The Evolution of Localised Technology Development Policy

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This review of spatial innovation literature explores the evolution of initiatives to promote innovation by firms in local and regional settings. First stimulated by the evident success of Silicon Valley, California in the 1970s and 1980s, many national and regional governments sought to encourage the formation of high technology industry complexes by earmarking budgets and special high-tech development zones, modelled, to some extent, on the pattern established by the science park at Stanford University, founded in 1951 (Castells and Hall 1994). It is well-known that Frederick Terman, later Provost and Vice-President at Stanford, was the driving force behind Stanford Industrial Park, as it was officially known, and that among his student entrepreneurs were the founders of Litton Industries, and later Hewlett and Packard, preceded as tenants on the park by Varian and succeeded by Fairchild Semiconductors. Fairchild was the matrix for Intel, National Semiconductors, American Micro Devices and some forty other US chip-manufacturers from 1957, when the "Shockley eight" began to find their feet.

What is less well-known, perhaps, is that much of this history arose from an initial institutional borrowing and learning process in which knowledge-transfer from the Massachusetts Institute of Technology (MIT) was crucial. First, from working on a wartime military project at MIT, Terman realised that the electrical engineering programmes there and elsewhere on the east coast of the USA were far superior to those of Stanford, and he sought to emulate them. But second, he also realised that university-industry relations were much stronger, particularly at MIT, which was substantially dependent on industry funding for its research and educational programmes. Third, in order to build up Stan-

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ford's academic and industrial liaison strengths, technology transfer from the east coast was also a necessary condition for innovative industrial development. This was assisted considerably by the foundation by William Shockley of Shockley Semiconductors near Stanford; Shockley having left Bell Laboratories in New Jersey in 1954, to capitalise on his invention of the transistor.

Stressing the first rather than the second part of the story fitted in well with the dominant linear model of innovation then at the forefront of understanding of the relationship between scientific progress and the commercialisation of products and processes. It is also clear, with hindsight, that for the truly radical innovations of semiconductors, integrated circuits and microprocessors, technology-push was a significant impulse, at least in relation to civilian applications. Even so, the role of the Department of Defence and the National Aeronautics and Space Administration as users of miniaturised computers and guidance systems has perhaps been highlighted less than their role as suppliers of large-scale funding for the development of microcircuitry. We still know relatively little about the nature and extent of interaction between users and technologists at the early stage of the development of these new technologies, though it has been argued that 67% of the functional source of innovation development for semiconductors was users and only 21% manufacturers (von Hippel 1988: 4).

To return to the efforts by policy-makers to model high tech innovation on developments at Stanford and Silicon Valley, it is clear that most approaches have involved the idea of co-locating research centres and innovation-intensive firms in science and technology parks. In some cases this has involved designating whole cities as Science Cities or Technopoles. Although benefits have accrued from such plans, there is also in the literature that reviews such developments a frequent sense of disappointment that more has not been achieved. In cases drawn from France and Japan, countries that have arguably proceeded furthest with the technopolis policy, a certain absence of synergies has been observed among co-located laboratories and firms. Nowadays, in response to the improvement in understanding of innovation as an interactive, possibly systemic process, more attention is paid to the factors that lead to embeddedness amongst firms and innovation support organisations (Granovetter 1985). This anthropological idea refers to the institutional and organisational features of community and solidarity, the exercise of "social capital" (Putnam 1993; Cooke and Wills 1999) and the foundations of high-trust, networked types of relationship among firms and organisations. To some extent also, there is emerging recognition that science parks are a valuable element but not the only or main objective of a localised or regionalised innovation strategy. A good deal of research has been conducted which helps understanding of the nature and range of interaction among firms and organisations engaged in innovation (see, for example, Edquist 1997; Braczyk et al 1998; Cooke and Morgan 1998; de la Mothe and Paquet 1998; Acs 2000) and policy is moving towards a notion of the region as an important level at which strategic innovation support is appropriate

(Cooke 1992; Tödtling and Sedlacek 1997; Cooke,2000a; Cooke et al 2000).

The clear difference between linear technopole and innovative 'cluster' policies is that the former is hierarchically planned, agglomeration is induced but no effort is made to create linkage, while the latter is more organically evolved, networking is promoted and linkage stimulated. At a significant strategic level the Regional Innovation System may encompass many clusters (Cooke 2000b) and other forms like supply chains or even company-towns, but all may benefit from systemic knowledge and innovation flows.

The second section examines examples of the *Interactive-Model Innovation Complex* in which, to some extent, learning gained from observing the weaknesses of linear-model approaches was integrated into the design of more networked solutions.

Finally, the most recent thinking about the design of *Regional Innovation Systems* will be presented and some prototypical examples will be discussed and evaluated. Conclusions will then be drawn concerning the key elements now considered essential to the optimal functioning of innovation support in terms of the multi-level governance of innovation.

Linear-Model Innovation Complexes

Two examples, one French the other Japanese, are presented to begin this section. The French were the first to experiment with the idea of Technopoles at Grenoble with Meylan-ZIRST (Industrial Zone for Research in Science and Technology). Many public and private research laboratories have located in this zone but few local synergies amongst smaller or even larger firms are evident. Our other example is the southern French case of Sophia Antipolis. This eventually succeeded, like Meylan-ZIRST, to attract government research laboratories and larger private investment but also like it, has been for a long time characterised by the relative absence of interactive innovation. Rallet and Torre (1998: 51) noted that despite strong specialisation in health technologies around Grenoble, research and training infrastructures were 'poorly connected' with local industry and industrial co-operation was for a long time 'considered insufficient'. De Bernardy (1999) also suggested that, to the extent collective learning was present in Rhône-Alpes, it was informal, fragile and vulnerable to market pressures.

Sophia Antipolis

Established in 1972 as a personal mission of Pierre Laffitte, co-director of the prestigious Paris *École des Mines*, it started slowly with little interest in the idea from business or the public sector. After 1975 a second launch was aimed at attracting R&D from US firms. Some, such as Digital, came and were joined by the French firms Thomson and L'Oréal, and government pharmacological and information technology laboratories followed. By the early 1990s Sophia Antipolis had 14,000 employees with 9,000 of them directly engaged in technological activities (Longhi and Quéré 1993). Among the US firms locating development units to introduce products to the European market were Cardis, Dow and Rockwell (in addition to Digital).

In Longhi and Quéré's evaluation the following key points are made:

- innovation networks are still marginal in Sophia Antipolis, especially regarding local activities and employment. While Digital and Thomson have organised a local network, as have two pharmacological firms, interacting with production and research skills locally, few dynamic innovations have ensued and learning from local partnerships is minimal.
- where a few linkages do exist they are almost exclusively vertical, never horizontal. This is because firms are isolated from their parent organisations and they fear "poaching" from other co-located laboratories. Further, there is active *mistrust* between innovative large firms and local research institutions although not between the latter and local small, innovative firms. The fear of losing proprietary know-how is behind this mistrust.
- there is no local labour market. There is almost no mobility between firms or organisations. In each case an internal labour market operates. The risk of information exchange is the main reason for this absence of labour market mobility. This is the single most obvious instance of the lack of an innovative network or milieu culture at Sophia Antipolis.

In terms of learning from this experience, the following five points are of considerable significance:

- there are weak signs of innovative interaction between larger firms seeking, for example, locally available software services,
- some French firms are being attracted to Sophia Antipolis by aspects of its critical mass and network potential,
- more new firms are, however, needed to create sufficient critical mass for synergies and creative innovation,
- where external networking exists it largely remains as a vertical, subcontracting type or relationship,
- the public sector policy networks are the most significant factor in potentially building up local innovative networks. So far, their main focus has been on "selling square metres".

Thus, Longhi and Quéré (1993) conclude Sophia Antipolis is only a qualified and rather one-dimensional economic success. A more recent paper by Longhi (1999) underlines the missing preconditions for collective learning by reference to the absence of a science base, spin-off firms and weak local interactions.

However, some moderation of the position occurred when the University of Nice moved its IT departments to Sophia-Antipolis in 1986, helping create a local labour market supply resource. Global firms are making stronger local linkages with start-ups and research institutes. Elements of a localised form of systemic innovation have begun to emerge after 25 years.

Three Japanese Examples of Technopoles: Tsukuba, Kansai and Sendai

The three examples selected to show differences in the Japanese approach reflect three phases in the development of the technopolis idea.

Phase I: Public Science-led Technopole -- Tsukuba

Tsukuba originated in 1958 as a satellite Science City for Tokyo. Tsukuba met the criteria regarding infrastructure, location and transportation later used to judge which cities would join the Technopolis Programme. It was mainly government-funded, the Japan Housing Corporation built housing for nearly 125,000 people and the Ministry of Construction paid for infrastructure. Laboratories and a Science and Technology University were relocated to the Science City. Only in the 1980s did private industry show interest in the site, following construction of a motorway to service the International Science and Technology Expo of 1985.

Public investment by 1990 was $1.1 billion. But many national research institutes (e.g. Inorganic Materials; Disaster Prevention; High Energy Physics; Health and Hygiene; and Environment) continue to experience difficulties in developing linkages other than the *vertical* ones typical of Japanese government agencies. Hence they do not share facilities or link to universities or private industry. There is also a lack of new spin-off firms. Tsukuba is seen as an isolated island although in the 1990s more local conferences and information exchanges have begun to occur. But, in general, there is relatively little synergy amongst organisations.

Phase II: Private-Sector Initiative -- Kansai Science City

This complex links the major centres of Kyoto, Kobe, Osaka and Nara. Its core is the Cultural and Scientific Research District, work on which began only in the 1980s. The centre of gravity is near Kyoto and the District aims at a population of 180,000. Thus Kansai is not a *pole* but rather an urban network of twelve polycentric but linked Science City areas. This complexity echoes the source of initiative which is the *private sector*. Large firms like Sumitomo, Matsushita (Panasonic) and Kawasaki Steel are the main sponsors, seeking to move into “sunrise industries.”

Amongst the major projects attracted are:

- Advanced Telecommunications Research Institute International
- Doshisha University
- Osaka Electro-Communications University
- International Institute for Advanced Studies
- Ion Engineering Research Institute
- Hi-Touch Research Park
- Private Companies (NTT; Sumitomo, Kyocera, CSK, Matsushita and Shimazu)

Some moves, (e.g. for research institutes) are publicly subsidised up to 33%. Collaboration among research institutes is quite high and, overall, knowledge-exchange is encouraged in Japan and internationally. Kansai is considered successful because it works with existing networks rather than trying to set up wholly new ones which inevitably take time to mature.

Phase III: Public-Private Initiative in the Technopolis Programme - Sendai

Sendai is 300 kilometres north of Tokyo, but in the congested Tokaido growth corridor. Sendai has 10 universities including Tohoku University, a research facility with special expertise in semiconductors. Sendai is the Mother City with 800,000 population. There are presently two sites: the Sendai Hokubu Research and Industrial Park; and Izumi Industrial Park which includes the 21st Century Plaza which forms the research core of the technopolis. It is an industrial support centre based on high technology development and exchange. It consists of a Regional Professional Training Centre, Incubator Laboratories, a Convention Centre, a Research-Industry Park and (in preparation) a University of Science and Technology.

Private investment is responsible for the housing construction and land is owned by the Mitsubishi Estate Company. It will eventually house 50,000 in 13,500 homes, the largest private housing scheme in Japan. Companies occupying the industrial park include Motorola, Toshiba and Toyota, specialising in electronics and new materials. The Tohoku "Intelligent Cosmos Plan" is associated with the development and seeks to stimulate regional technological development through university-industry linkage. One company, ICR-KK facilitates industrial applications of university R&D (70:30 public:private). ICR can license university patents and use the fees as it wishes.

In a recent assessment of the Sendai Technopolis, Abe (1997) suggested that, thus far, this technopolis displayed many of the overall limitations of the Japanese technopolis programme overall, especially the "branch-plant syndrome", relative absence of synergies between different agencies and organisations, little linkage between relocating large firms and indigenous

SMEs, and few spin-off firms from university or research institute scientific and technological activities.

It may be too soon to judge the technopolis programme, and the Japanese are famous for their long-term perspective of 20-30 years before expecting a significant return on investment, unlike evaluators and banks in Europe and North America. However, these ambitious plans seem thus far to display many of the short-to-medium term problems experienced by the French technopoles, namely lack of interactive innovation in the region or locality.

Interactive-Model Innovation Complexes

Distinct from the linear-model innovation complex, which -- as shown in the previous section -- is dependent either on large scale public infrastructure investment or large scale 'marketised' use of government research funding, is the "network" approach; this approach is more typical of Germany, Austria and the Nordic Countries. In this section, a number of cases from these countries will be outlined, pointing to the planned, interactive enterprise-support approach, based on close university-industry cooperation that is typical of them.

North Rhine-Westphalia

North Rhine-Westphalia has sought to develop innovation support policies since 1972. The NRW *Technical Board* established then, gave way to ZENIT, based at Mülheim and ZIM, for the Ruhr, subsequently ZIN, for the whole of the North Rhine Westphalia *Land* in the later 1970s and 1980s (Kilper and Fürst 1995).

In 1987, the *land* had set up the Zukunftsinitiative Montanregionen (ZIM -- initiative for the future of the coal and steel regions). Local actors were brought together and asked to decide, by consensus, which projects should be proposed to the *land* for funding. Rather than a programme being set up by *land* or local government, a broad range of actors in each locality, e.g. Chambers of Commerce and Trade, banks, local politicians, were brought together to form "regional conferences". These bodies had, and still have, no official or decision-making powers, but rather work alongside existing tiers of local government [Regierungsbezirke, Kreise/cities, Gemeinde which may be compared to counties, (metropolitan) districts, communities]. Under ZIM, the regional conferences decided, by consensus, on projects for their localities, which were then proposed to the *land* for funding. Action areas were: innovation and technology; training for the future; infrastructural modernisation; improvements to energy and the environment. The *land* funded 300 out of 1200 projects. In 1989, "Zukunftsinitiative für die Regionen Nordrhein-Westfalens" (ZIN 1 initiative for the future of NRW's regions) was set up for all the *land's* 15 regions. Regional fora were set up, involving a broad range of actors within localities e.g. local government, Chambers of Commerce and industry and banks.

Under ZIN 1, greater emphasis was laid on strategy than under ZIM, but the same action areas applied. The *land* gave DM 1.1 billion to 330 projects out of 2,000 proposed. ZIN 2 followed in 1990, when the *land* decided that each region should compile a "Regionale Entwicklungskonzept" (REK -- regional development programme) based on an empirical analysis of its economic situation, and setting out a strategy for future development.

It has recently been proposed that the REKs should move towards forming the *land's* regional policies. This is a significant development, because it gives considerably more strategic power to non-elected regional conferences or fora. Such conferences will propose projects to the *land* government which, if approved, will commit the regional administrative authorities within the *land* to carrying them out. The *land* controls this process through allocating resources earmarked for the proposed projects to the regional administrations for them to carry out even though they have not actually initiated them.

In November 1991, the "Initiative Bergbautechnik" (mining technology initiative) was set up by the Ministry of Economics and the Ministry for Work, Health and Social Affairs in order to facilitate the implementation of structural changes in the Emscher-Lippe region, the eastern Ruhrgebiet and Aachen-Heinsberg's coal area. The private sector participates in the programme -- both *Mittelstand* and large firms, as well as the Chambers of Commerce and industry. The 1992-1995 programme is funded by the EC.

A number of technology centres have been set up under the NRW Technology Programme. These have the aim of bringing together innovative and technological activities and firms in the hope of creating synergies, which will then have effects throughout the region. The centres are part of a process of restructuring and modernising the *land* economy, helping to create highly-qualified, techno-logy-oriented jobs. Firms are offered a range of services including cheap office, R&D and production space; reception and telephone facilities; cafeteria, business advice and conference rooms. Networking and exchange of ideas and information are seen as crucial to the success of the centres. The state is perceived as having an important facilitative role in this process. However, initiatives to set up technology centres usually come from the local, grassroots, level and generally take the form of public private partnerships. At present there are 31 Technology Centres in NRW and a further 12 are projected for establishment in the near future.

Learning and improvement of network mechanisms have occurred during the lengthy period during which the North Rhine-Westphalia programme has been in operation. In brief, these can be summarised as follows:

- to assist in keeping new companies in the region it is important to link any centre (higher education institute, science park etc.) responsible for their establishment with a technology park where they can, for comparable rents, turn research into product.

- the network should not focus on a few technological areas. This is because of the accepted difficulty in "picking winners." In any case, networks of the kind under discussion tend not to be highly specialised. A "technology mix" concept in which there is variety in the fields of expertise is to be favoured.
- professional management of the network is absolutely essential. Personnel with experience of running a company, running the technology development area of a large company, or engaging in consultancy in technology fields of direct relevance to the network are optimal.
- there needs to be a regional technology development strategy or Regional Technology Plan for the promotion of an innovation infrastructure. Integration of local actors and shareholders of the network organisation is crucial.
- a survey of existing infrastructure and likely customer demand for innovation services is a prerequisite for establishing a facility likely to be in demand by firms in the innovation market place.

Moreover, change in the development of policies is something requiring acceptance by network managers. The example of *PlaNet Ruhr* is instructive in this respect. Here, the basic idea was to integrate scientific organisations, consultants, chambers of commerce and other relevant agencies in a regional network of organisations. The intention was that it should disseminate information and know-how assisting business restructuring and, in the process, introduce one or more of ten possible new processes in production. It proved difficult to integrate the network; people involved changed, some network members could not devote sufficient time, and training offers often did not fit the needs of the firms. The network was in danger of disintegrating. But instead of walking away, the members reorganised the network by separating different functions. The consultants worked in their sphere, the trainers in theirs and they were able to speak in a more focused way to their clients and the policy network behind the initiative. The network and the initiative still function after a number of years and co-ordination is now more appropriate to firm requirements.

Technical University of Graz, Austria

In 1993 a project was established to provide active technology transfer from the university to both start-up and established regional enterprises. The partners were the university and the city council. The key aim was to identify some 70 firms suitable for this, to visit them and market the relevant services of the university to them and to stimulate cooperation between them and scientists. This involved computerised identification of know-how, a company audit, problem identification and solution with consequent after-care. During the 70 meetings some 200 concrete requests for knowledge transfer were identified and solutions took the following form:

- providing access to research thesis findings of relevance
- informal consulting by a university consultant-pool
- use of university technology services
- contracts for small scale research by university research assistants
- job offers from firms for students and alumni

In addition, Graz has five technology parks for new business start-ups. New start-ups are encouraged from amongst graduating Ph.D. students. Each June some hundred are invited to an Open Day on "Setting up a new technology-based firm". They are addressed by previous students who have successfully established businesses and, on average, three new start-ups are established per year. They receive a low-rent unit on the Technology Park at the university provided their new business is not directly competing with an existing firm. In this way new spin-offs are protected from predatory competition from the outset and they are encouraged to interact, learn and even cooperate with complementary firms in the informal approach the Austrians call "coffee-break knowledge transfer". Over one hundred new start-ups are now in existence at Graz, (Cooke 1996).

Oulu Technopolis Finland

The Oulu case is interesting enough to have been profiled in the *Financial Times* and *Business Week* because of its location close to the Arctic Circle and because it represents the largest concentration of high-tech firms in Finland at 300 in 1996, of which 100 start-ups date from 1985 at the earliest. The University of Oulu is largely responsible, having set up the Technical Research Centre in 1974, the Oulu technology park in 1982, and the Medipolis medical science park in 1990.

However the technopolis does not only house small start-up firms. Nokia brought its first operations to the technology park in the 1970s and now employs 5,000 in R&D and the production of base stations for mobile telephony. Some of Nokia's sub-suppliers in printed circuit boards, base station technology and electronics systems have followed. But this does not edge out the start-ups, rather it provides many of them with an immediate market through local sub-contracting opportunities. Hence a virtuous circle of interaction now exists between large telecommunications firms, smaller start-ups and the Technical Research Centre, with systemic knowledge-transfer amongst them.

The Medipolis has some 50 firms and most originated with Ph.D. graduates establishing businesses researching and producing advanced medical equipment and products. Because medical technology is a global business, with the USA and other European health systems being major purchasers, familiar with buying from and collaborating with innovative spin-offs, there are no large firms on the Medipolis. In 1996 employment on the Technology Park (without Nokia) was 1,200 and at the Medipolis, 300 (Jussila and Segerståhl 1997).

Linköping University, Sweden

This university was founded in 1972, its largest faculty being the Institute of Technology, covering 40 fields in eight departments. The university has established and encouraged a tradition of technology-transfer by staff. In 1984 a group of entrepreneurs and start-up owner-managers joined forces with the university to establish the Foundation for Small Business Development (SMIL), not least because some 40 spin-off firms had been established in the early 1980s, mostly from the university but some from Ericsson and Saab, located near the university. SMIL offers membership to small technology-based firms and enterprise support groups. It now has 150 members. Membership costs £150 annually. The first SMIL activities involved building a network of technology-based entrepreneurs, advising them, promoting exchanges, assisting with management resources and providing marketing support. SMIL has a separate secretariat at the university.

Working closely with SMIL is the university's Centre for Innovation and Entrepreneurship (CIE) the task of which is to stimulate *growth* amongst the SMIL members through new business development programmes, problem-solving groups of owner-managers, management training and club/networking activities. This approach, centred on the local Mjardevi Science Park, has enabled academic-based firms to, in one case, reach the 800-employee mark, with three others employing over 100, and a total of approximately 100 surviving start-ups employing between one and five persons. In total, some 1,500 jobs in advanced, mainly information technology companies can be traced back to the activities of the Institute of Technology, SMIL and CIE at Linköping University. Again, as with Oulu, the co-location of university, large technology-intensive firms like Ericsson, Saab and some suppliers, and the innovative start-up firms constitutes a systemic innovation arrangement in which knowledge-transfer moves among the three kinds of partner, and small firms receive some security as a base for market growth from having, on the one hand, a customer market locally and, on the other, sources of knowledge and technology-transfer plus management advice close by (Jones-Evans and Klofsten 1997).

Local Networking: the Case of Aarhus

The Aarhus region, bordered by the towns of Randers, Silkeborg and Skanderborg, with 600,000 inhabitants, is one of the most important economic areas of Denmark. Together with the food technology and environmental science sectors which dominate the region, there are also numerous biotechnology companies, energy technology, electronics and software firms. Food processing is the largest industrial sector and accounts for more than a third of all employees in the private sector. More than 80% of employees in the private sector work in establishments with less than 50 employees. The remaining 20% generally work in medium-sized companies. There are only a few companies with more than 1000 employees.

In 1991, the local council of Aarhus launched an industrial development initiative known as 'Plan 2001' aimed at generating 20,000 new jobs through a structure of public/private dialogue and private/private interaction. The key elements of Plan 2001 include the introduction of the following:

- Growth groups
- Innovation contracts
- Business advisory agency
- Venture capital investment company
- Agri-food forum
- International investment location initiative
- Establishment of Knowledge Centres.

Although in principle the objective of Plan 2001 encompassed all firms, it sought to get initiatives up and running as quickly as possible in order to create early successes which would serve as good examples and thereby create snowball effects through the force of example. The basis for exerting influence consists of the promotion of 'organic' networks (Grabher 1993) involving the groups, organisations and also companies that themselves have an ongoing contact with many companies, and that have a self-interest in strengthening their business clients. As a result they are in a position to stimulate awareness of initiatives via an indirect information exchange. Other candidates involved in this dissemination process are the larger companies with numerous subcontractors, wholesalers and retailers, public sector purchasers and also industrial and trade organisations, employers associations and trade unions (Nielsen 1994).

Towards Regional Innovation Systems

Each of the examples outlined in the previous section is clearly more successful than technopoles in taking innovation from the science base to the market through commercialisation, particularly through systemic, innovative new firm formation. They are interactive systems, but not all, indeed rather few, operate at a regional level. Taking each element of the term 'Regional Innovation Systems' in turn, the concept "region" recognises the widespread existence of an important level of industry governance between the national and the local. To varying degrees, regional governance is expressed in both private representative organisations such as branches of industry associations and chambers of commerce, and public organisations such as regional ministries with devolved powers concerning enterprise and innovation support, particularly for SMEs. Furthermore, there are few regions thus-defined that do not possess increasingly important universities or polytechnics that can look outward to industry either for research commissions or as incubators for innovative start-up firms.

"Innovation" refers to the process of commercialising new knowledge, possibly though not necessarily emanating from universities, with respect to product, process or organisational innovation. As we have seen, this is now better understood as a complex process involving users, producers and various intermediary organisations learning from each other regarding demand and supply capabilities and exchanging both tacit and codified knowledge. Indeed innovation can be characterised as a knowledge transfer and realisation process involving actors whether internal or external to the specific firm operating as a project-based team or project-network. The "systemic" dimension of the term under discussion derives in part from this team-like character associated with innovation. While, as Lundvall (1992) puts it, an innovation system is a set of relationships between entities or nodal points involved in innovation, it is really much more than this. Such relationships, to be systemic, must involve some degree of inter-dependence; not all relationships may be equally strong all of the time, but some may be; and there may be hierarchical elements in the system as well as powerful elements that, nevertheless, act more in a backstage rather than a front-stage manner. An example of a systemic regional innovation relationship is as follows, based on an actual case reported in Cooke and Schall (1997).

A firm, continuously innovating in a specific kind of automotive component, becomes the partner of a local university engineering department. The partnership is focused on an innovative programme, administered by the university but funded jointly by the national research council, the regional industry ministry and the firm, to enable a doctoral student to write his or her thesis on a subject of direct relevance to the firm's innovation needs. As one student completes the dissertation and perhaps becomes an employee of the firm, the programme yields up a new doctoral candidate to solve the next generation of innovation problem. When asked: what if the programme ceases?, the research director's immediate response is that the firm would have to fund the studentship. In other words, this process of knowledge-transfer has become systemic for the firm.

Some regional systems are better-equipped to do this than others as has recently been argued (Cooke et al 1998; Cooke et al 2000). In ideal-typical terms Table 1 summarises aspects of this difference.

In the remainder of this section, brief accounts will be given of three instances of regional innovation systems which tend to be located at different evolutionary points on the scale from strong to weak, but which also have high consciousness of the importance of systemic regional innovation. These are

Baden-Württemberg, in Germany, Emilia-Romagna, in Italy, and Wales, in the UK (for further detail, see Cooke and Morgan 1998).

Baden-Württemberg

As a German *land* Baden-Württemberg has substantial taxing, spending and policy authority. Firms in the region, in common with the German model, operate cooperative workplace practices through co-determination; externalisation of production and services in integrated supply-chains is a normal feature of the industrial landscape; and innovation is highly promoted and pursued. Policy-making is inclusive and open to influence from key private actors; monitoring and foresight functions are well-established and, periodically, arrangements such as the Future Commission on "Economy 2000" offer inclusive advice on the future steering of the economy. Consultation is thus widely-practised. Institu-tionally-speaking the *land* is characterised by a consensual, associative governance culture and a strong learning disposition.

Baden-Württemberg has most of the features associated with a strong regional innovation system. This is not to say that it is thereby immune from the

TABLE 1 Characteristics of Regions with Strong and Weak Systemic Innovation Potential.

	STRONG Regional Innovation system POTENTIAL	WEAK Regional System of Innovation POTENTIAL
Infrastructural Level	Autonomous Taxing and Spending Regionalised Private Finance Strategic Infrastructure Competence Embedded Universities/R&D Labs	Decentralised Spending or Taxation National Private Finance Few Infrastructure Competences Disembedded Univ./ R&D Labs
Organisational Level: Firms	Workplace Cooperation Externalisation Innovation	Workplace Antagonism Internalisation Adaptation
Organisational Level: Policy	Inclusive Monitoring Consultation	Exclusive Reacting Authorisation
Institutional Level	Consensus Associative Learning Disposition	Dissensus Individualistic Introspective

serious economic pressures imposed by external processes, such as globalisation, or internal problems deriving from a systemic tendency to have become "locked-in" to an automotive, electronics and mechanical engineering "monoculture". Moreover, in its attempts to steer a trajectory more towards the future industries of multimedia, biotechnology and environmental technologies (e. g. solar energy) problems are being experienced. Thus the iTV initiative proved unsuccessful because of technological and cultural incompatibilities between the large telecom and computing firms (Alcatel-SEL, Bosch, Telecom, Deutsche Telekom, Hewlett-Packard and IBM) the Ministry of Economics had networked into a consortium. Nevertheless, future-oriented initiatives of this kind offer learning opportunities in themselves, although it still remains to be seen how successfully the *land* can help re-track a future development strategy for the economy, something which is perhaps the ultimate test of a strong regional innovation system. One sign of progress has been the success of the Heidelberg region in being selected as one of Germany's three, federally-funded BioRegios, the aim of which is to speed-up commercialisation of biotechnology through interactive innovation and cluster-building.

Emilia-Romagna

Emilia-Romagna, as an *ordinary* statute region in Italy unlike the *special* statute regions such as Friuli-Venezia-Giulia or Sicily, has considerable taxing autonomy but little spending autonomy. This means, the regional government has only moderate capacity to develop innovation and other economic initiatives, though it achieves much within these limited financial parameters. While there are numerous regional and even local financial institutions which are valuable sources of support for the myriad SMEs in the economy, there is little strategic infrastructural competence and universities are not embedded in the industrial fabric, though the national research institute ENEA is, through its policy of supporting technology-transfer to SMEs. Workplace cooperation is high, externalisation by firms through commissioning and sub-contracting of work is high and innovation is very high, but incremental rather than radical, and R&D expenditure is low -- reflecting the dominance in the economy of SMEs.

In terms of policy-development the regional governance organisations are highly inclusive and well-networked with representative organisations of industry from *Confindustria* (the national industry body) to the powerful local chambers of commerce. As in Baden-Württemberg, periodic commissions under the aegis of the Regional President, monitor the regional economic trajectory, supplementing the work of the regional ministries and ERVET, the regional development agency. Changes in policy towards innovation, such as the recent changes in funding régime for the localised business innovation and services centres, are the product of wide consultation. The regional governance and business culture is thus consensual, associative in that many representative organisations of economic consequence are part of the information and interaction process, and the antennae of the region are highly-attuned to learning and tutoring opportunities.

Emilia-Romagna is a weaker innovation system than Baden-Württemberg because of its industrial structure (SMEs), the history of disembeddedness of its few knowledge-centres and its budgetary constraints. Problems in relation to innovation have been tackled in a localised and limited way. There is recognition that while some local business innovation centres are dynamic, not all are, and even the dynamic ones must develop the capacity to link with universities and research institutes outside the region. This is needed to help maintain the competitiveness of SMEs specialised in industrial districts and often in mature consumer sectors subject to severe global competition.

Wales

Wales has the weakest of the three regional economies under discussion because it is still in the process of reconversion from its historic dependence upon heavy industry. It has no taxation autonomy but has traditionally had spending autonomy over its block-grant allocation from London, negotiated in Cabinet by the appointed Secretary of State. When devolution was voted for in the September 1997 referendum Wales was denied taxation or primary legislation powers in its projected Assembly, established in 1999. There are relatively few Welsh banks, these having been absorbed into the UK system over the long-term. However, the Assembly controls budgets for roads, universities, factory-building, training and innovation support and has been active in securing a doubling of European Union Structural Funds to assist infrastructure development. Of some importance recently has been the receptivity of governance organisations, universities and business to developing one of the EU's first Regional Technology Plans (now re-named Regional Innovation Strategies). Universities are quite well-embedded with the industrial fabric though there is a paucity of independent research institutes.

The Regional Technology Plan (RTP) proved an indicator of the perhaps underestimated capacity for inclusiveness and consultation on the part of a hitherto hierarchical economic development administration, previously dominated by the Welsh Office and Welsh Development Agency. Firms were known to have developed a culture of workplace cooperation following a long history of antagonistic industrial relations in the coal and steel industries. Modern industries such as automotive and electronics externalise much of their production to local and national supply-chains despite the leading firms having a mainly foreign-ownership profile. A consensus on the importance of innovation to the future development of the economy has emerged and "associational" practices have been encouraged by the main governance organisations through the animation of numerous business fora, supplier clubs and the like. A strong learning disposition both internally and externally to the regional economy has also evolved, not least through formal partnerships with European regions like Baden-Württemberg, Catalonia and Lombardy.

Wales thus represents a case of a fairly weak innovation environment having evolved some of the features of a stronger innovation system, though systemic relationships still tend to be loosely-coupled sub-systems focused on enterprise support, vocational training and university-industry innovation linkages. Of considerable recent importance has been the influence of and receptivity to European Union policy towards the stimulation of systemic regional innovation. This reflects a degree of frustration with the neo-market experimentation of the Conservative government during the 1980s and 1990s which, in a peripheral setting, meant innovation was left to market forces with scarce support from the UK government. The EU approach, which seeks to build up institutional and organisational innovation-support capacity is better-attuned to the needs of regional economies that have suffered from the past effects of market-failure.

Multi-Level Governance of Innovation

These contrasting examples of more-or-less developed regional innovation systems point to interesting variations in the nature and extent of multi-level governance of innovation. Clearly regional innovation, whether systemic or not, does not operate in an insular fashion. Global, national and even local factors intervene. In Table 2 an attempt is made to summarise key features of the differences between the regions discussed in terms of key innovation impulses, and the nature and degree of systemic interaction surrounding innovation in the regions concerned.

The main conclusions from considering the information in Table 2 are that the capacity to develop systemic innovation at the regional level is mainly contingent upon the extent of regional economic power in relation to governance capa-

TABLE 2 Comparisons of Multi-Level Governance of Regional Innovation.

	Baden-Württemberg	Emilia-Romagna	Wales
Governance of Innovation	Federal and Regional	Regional	Eur. Union & Regional
Innovative Firms	Regional	Reg. & Local	Global and Regional
Infrastructural Competence	Relatively Autonomous	Dependent	Semi-autonomous
Policy Regime	Inclusive	Consultative	Authoritative
Innovation Culture	Associative Learning	Associative and Learning	Learning to be Associative

cities and the extent to which the regional economy is internally articulated. While the national or federal level is obviously important in setting the scene for innovation and constructing the rules of the game for incentives, it may also create conditions which either do little to stimulate regional innovation or may pursue policies which act as barriers to it. Where regional policy capacity is relatively high even if regional budgets may not be, innovative governance may seek support for innovation through focusing downwards to the local level, as happened in Emilia-Romagna, or upwards to the EU level, as happened in

Wales. Of considerable importance to generating the impulse to seek ways of assisting systemic innovation is the combination of the policy regime operating in the region and the institutional base or culture with which it interacts. Where these are inclusive or consultative, and associative, respectively, they can be good grounds for the building of regional systems of *interactive* innovation.

Conclusions

It has been argued that as the model which best explains innovation processes amongst firms and scientific organisations has shifted from linear to interactive, so the model for promoting regional and local economic development based on the promotion of innovation has moved from a hierarchical to a more networked one. It was shown that early attempts to implant innovation activities in selected geographical spaces, by encouraging decentralisation of research laboratories and innovative firms to technopole environments, often produced rather disappointing results in terms of the achievement of stated objectives regarding exploitation of a projected "synergetic surplus" for innovation. Can technopoles be saved? Only if they absorb the lessons of interactive innovation systems, by enhancing social capital, networking and intermediary activity. This has recently begun to happen at Sophia Antipolis with the arrival of University research departments with active spin-off policies.

Policies that sought to promote interaction between different innovation actors that had good reasons to interact, such as universities or research institutes, small start-up firms and larger customer firms, as practised in Scandinavia, Germany and Austria produced more satisfactory results in relation to less ambitious goals. A point has now been reached where innovative policy-thinking has evolved towards a broadening of the network approach to encompass regional innovation systems. These may embody localised interactive networks but also include the wider business community and governance structure to maximise the financial and associational assets of regions for the promotion of innovation. For the moment it seems that there is no single model of the successful regional innovation system. But a reasonably high degree of regional economic and policy autonomy, a willingness to recognise the multi-level nature of innovation governance, an inclusive and consultative policy mentality and an associative culture attuned to the importance of innovation for growth and jobs, are important ingredients in the successful promotion of innovation for the future.

References

Abe, S. 1997. "The Regional Innovation System of Tohoku, Japan", in H.

Braczyk. P. Cooke, M. Heidenreich (eds.). *Regional Innovation Systems.* London: UCL Press.

Acs, Z. 2000. *Regional Innovation, Knowledge and Global Change*. London: Pinter.

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

Castells, M. and P. Hall. 1994. *Technopoles of the World.* London: Routledge.

Cooke, P. 1992. "Regional Innovation Systems: Competitive Regulation in the New Europe". *Geoforum*, 23: 365-382.

_______. 1996. *Networking for Competitive Advantage*. Dublin: National Economic and Social Council.

_______. 2000a. "Business Processes in Regional Innovation Systems in the European Union", in Z. Acs (ed.). *Regional Innovation, Knowledge and Global Change.* London: Pinter.

_______. 2000b "Biotechnology Clusters in the UK: Lessons from Localisation in the Commercialisation of Science". Paper presented at Conference on *Comparing the Development of Biotechnology Clusters*, Center of Technology Assessment, Stuttgart, January 27-28.

Cooke, P., and N. Schall. 1997. "The Promotion of Systemic Regional Innovation in Wales". Paper presented at the *International Conference on Comparative Regional Studies.* Sendai International Centre, Japan, 16-21 September.

Cooke, P. and K. Morgan. 1998. *The Associational Economy: Firms, Regions and Innovation.* Oxford: Oxford University Press.

Cooke, P., M. Uranga and G. Etxebarria. 1998. "Regional Systems of Innovation: an Evolutionary Perspective". *Environment and Planning A*, 30: 1563-1584.

Cooke, P. and D. Wills. 1999. "Small Firms, Social Capital and the Enhancement of Business Performance through Innovation Programmes". *Small Business Economics,* 13: 219-234.

Cooke, P., P. Boekholt and F. Tödtling. 2000. *The Governance of Innovation in Europe*. London: Pinter.

De Bernardy, M. 1999. "Reactive and Proactive Local Territory: Co-operation and Community in Grenoble". *Regional Studies*, 33: 343-352.

De la Mothe, J. and G. Paquet. 1998. *Local and Regional Systems of Innovation.* Dordrecht: Kluwer.

Edquist, C. 1997. *Systems of Innovation.* London: Pinter.

Grabher, G. 1993. *The Embedded Firm.* London: Routledge.

Granovetter, M. 1985. "Economic Action and Social Structure: the Problem of Embeddedness". *American Journal of Sociology*, 91: 481-510.

Jones-Evans, D. and M. Klofsten. 1997. "Universities and Local Economic Development: the Case of Linköping". *European Planning Studies*, 5: 77-93.

Jüssila, H. and B. Segerståhl. 1997. "Technology Centres as Business

Environments in Small Cities". *European Planning Studies*, 5: 371-384.
Kilper, H. and D. Fürst. 1995. "The Innovative Power of Regional Policy Networks: A Comparison of Two Approaches To Political Modernization in North Rhine-Westphalia". *European Planning Studies*, 3: 287-304.
Körfer, H. and E. Latniak. 1994. "Approaches to Technology Policy and Regional Milieux: Experiences of Programmes and Projects in North-Rhine-Westphalia". *European Planning Studies*, 2: 303-320.
Longhi, C. and M. Quéré. 1993. "Innovative Networks and the Technopolis Phenomenon: The Case of Sophia-Antipolis". *Environment and Planning C: Government and Policy,* 11: 317-330.
Longhi, C. 1999. "Networks, Collective Learning and Technology Development in Innovative High Technology Regions: The Case of Sophia-Antipolis". *Regional Studies*, 33: 333-342.
Lundvall, B. 1992. *National Systems of Innovation.* London: Pinter.
Nielsen, N. 1994. *The Concept of a Technological Service Infrastructure*. Paris: OECD.
Putnam, R. 1993. *Making Democracy Work*. Princeton: Princeton University Press.
Rallet, A. and A. Torre. 1998. "On Geography and Technology : Proximity Relations in localised Innovations Networks", in Steiner M. (ed.). *Clusters and Regional Specialisation.* London: Pion.
Tödtling, F. and S. Sedlacek. 1997. "Regional Economic Transformation and the Innovation System of Styria". *European Planning Studies*, 5: 43-64.
von Hippel, E. 1988. *The Sources of Innovation.* Oxford: Oxford University Press.