The New Wave of Regional Innovation Networks: Analysis, Characteristics and Strategy

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ABSTRACT. Today, the number one priority for competitive advantage is innovation. A new approach to regional business development has been pioneered in Europe and the U.S.A. This involves building a regional innovation infrastructure. Learning through "networking" has proven to be a successful approach in some of Europe's more dynamic regional economics such as Baden-Württemberg and Emilia-Romagna. This involves maximising the complete range of regional innovation assets. The state of Pennsylvania and other older industry centres are showing that such an approach is transferable from Europe to the U.S.A. The paper assesses knowledge-transfer at the regional level and outlines the key elements for successful regional innovation networking practices. The major finding(s) are that business networking is an effective way of increasing company turnover; that not-for-profit organizations are excellent for setting up networks because they are trusted, and that innovation networks are perhaps the most difficult, thought-requiring but important of the types of business network conceivable.

Introduction

Regional authorities throughout Europe have fashioned a new approach to regional development. This change was triggered by the growing recognition that regions can no longer compete simply by offering a crude combination of semi-skilled labour, on the one hand, and financial incentives for inward investment on the other. This kind of regional policy made little or no impact on the central problem of old industrial regions, namely, low innovation potential, a problem which afflicts both the indigenous small and medium enterprise (SME) sector and the branch-plant sector.

Today, all the most dynamic regions in Europe are of the view that their local firms need much more than a liberal macro-economic climate if they are to remain on an innovative footing. Strong regions like Baden-Württemberg and Emilia-Romagna as well as less favoured regions such as Valencia and the Basque Country are examples of regions that are trying to create a competitive edge for themselves by building a regional innovation infrastructure through which local firms have easy and affordable access to a wide array of technical services.

There are two important questions to be asked of these regional innovation infrastructures. First, how do they provide advantages for firms in the region? Second, what lessons can be learned from the more successful regional innovation systems? In answering these questions reference will be made to research on European and U.S. examples.

In the European Commission's Community Support Frameworks and in thinking about Regional Technology Strategies (RETAS: see Hingel, 1992; now known officially as Regional Technology Plans or RTPs) support for research and development (R&D) is often identified as a key item. In particular, stress is placed on diffusion and transfer facilities such as Science and Technology Parks, Applied Research Centres, Innovation Centres and various kinds of technology support vehicles for business. While all of these facilities are commendable it is important that a coherent package of initiatives which suits the regional economy is put in place. Thus, rather than attempting a purely "top-down" strategy design, this paper focuses on a "bottom-up" approach. This approach integrates business needs,

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enhances existing support institutions and adds appropriate ingredients based on successful experiences elsewhere in Europe. The aim is to produce a coherent and achievable set of innovation objectives that benefit regional innovation and development.

Advantages to firms of regional innovation services

The key technological requirement of firms in innovation centres is that services should convey appropriate and relevant information and advice without being overly general or too elaborate. The presence of specific, appropriate and relevant information provides little guarantee of a firm's willingness to accept change.

Thus receptivity of firms to such services is an important factor in determining how well-synchronised supply is with demand. For example, German, Japanese and, other continental firms seem to have greater receptivity towards support of this kind than those in the U.K. and U.S.A.

If the willingness is present then the firms stand to benefit. Amongst the benefits that firms in innovation-rich regions receive from the innovation infrastructure are the following. First, technical resources: many firms need basic testing equipment, measurement, calculation and problem-solving support since these are usually too expensive to have in-house. The Basque Technological Centres are adept at providing this to SMEs. A second requirement is expert technological advice: more advanced demand and supply, often using sophisticated technologies such as CAD-CAM, or across the board applications in, for example, new telecommunication networks, are highly valued. Third, there are benefits to be derived from information services: facilities which can scan sources of value-adding information on, for example, patents, exploitable technologies, technical partners, or possible joint-venture partners, have immediate practical use. Fourth, gateway services: EC programmes enable SMEs to be brought into partnership with leading edge firms and research institutes. Innovation centres can act as gateway-members to such programmes. Finally, network services: innovation centres increasingly animate "competition through collaboration" via schemes which encourage SMEs to form groups and alliances so they may afford services together which individually they would be unable to.

Networks as the key to regional economic development

In the past, it was thought that decisions about innovation had to be made by the central government. The "technopole" idea, once the leading innovation concept, was a good example of this, but this is no longer leading the field. In its place is an emergent set of developmental practices which are commonly described as "networking" or "the network paradigm" (Cooke and Morgan, 1991). The key elements of networking are as follows:

Reciprocity – a willingness to exchange information, know-how, proprietary knowledge and goods (Powell, 1990).

Trust – a willingness to risk placing faith in the reliability of others (Sabel, 1992).

Learning – a recognition that knowledge develops and best-practice should be learnt (Lundvall, 1988).

Partnership – a preparedness to solidify reciprocal relationships preferentially (Sako, 1989).

Decentralism – a realisation that centralised information and decision-processing is inefficient (Aoki, 1986).

Many of these principles have been adopted by corporations confronted with the starkest of choices as to whether to continue on a downward path by following the old ways (e.g., the General Motors approach) or radically to transform corporate organization as Xerox did ten years ago, Ford Motor Co did between five and ten years ago and IBM is seeking to do at present (Morgan, Cooke and Price, 1992).

Networks in innovation

Evidence that this way of thinking underpins EC research and technology development policy comes from the Commission's DG XII report on "Science, Technology and Community Cohesion" (Hingel, 1992). The proposals arising from this document are based on the following research findings that are drawn from the actual practices

of innovation actors and institutions. The report relies on 28 dossiers which suggest the following:

(i) in the dozen or so "islands of innovation" in the EC core area there are dense networks of co-operation between innovation actors on local, inter-regional and international scales.
(ii) establishing new islands is possible (e.g., Munich – biotechnology; Grenoble – artificial intelligence; Toulouse – aeronautics) but difficult, costly and rare, with major public investment essential.
(iii) co-operation between the "innovation islands" and EC Objective 1 region researchers is higher (25%–35%) for EC programmes than for European co-operation networks in general (5%–8%).
(iv) such co-operations are long-term, personal and university-led. They are based on "comparable competences" in fields where the "periphery" has local sectoral strengths which produce innovative applications of generic technologies.
(v) diversity thus enhances learning capacities inside and outside the "islands of innovation" (e.g., big corporations learning "flexible specialisation" from peripheral SMEs). Diversity gives a head-start in specific industrial product and process sectors.
(vi) cohesion depends on interactive learning between local research and technology development actors and units, whether inside or outside the leading innovation islands.

In brief this is an optimistic but still realistic perspective on the development process. It recognizes that there is unevenness in the spread of major innovation centres but it opens the prospect of localised innovation built on sectoral specialisation outside of the major centres.[1]

Networking policy proposals

There are two ways to approach this analysis. First from a geographical dimension and next from a cohesion dimension which includes the fields of scientific and technological innovation (Table I). While both policy-dimensions are important, the geographical dimension is the more substantive. It is becoming obvious, even to economists, that the business world does not function on the head of a pin. Geographers have for long observed the importance of comparative spatial advantage and the role of networks in seeking to overcome these. Despite the recent work of Krugman (1991), some economists are only now beginning to wake up to the economic geography which economic actors understand implicitly. Most of the cohension proposals are meant to conserve local diversity by improving awareness, applications and the integration of EC policies with both Regional Technology Development (RTD) initiatives and local requirements and opportunities.

However, the geographical dimension involves concrete new proposals to create active regional and urban networks, to attach financial resources to these and to implement actions of a strictly developmental kind consequent upon assessments of need and opportunity. The idea of Free Science Parks is a case in point. One reason firms spend less on innovation than they might is that it is usually a taxable expenditure. If Free Science Parks, on the model of Free Ports, could be established, this would be a means of avoiding the penalisation of R&D expenditure. But of most

TABLE I
EC Regional technology development: Proposals for the future

Geographical dimension	Cohesion dimension
1. Integrated European programmes in RTD	1. RTD for local needs
2. City and regional RTD user networks	2. Gateway development programmes
3. Free science parks	3. Relay centres to exploit RTD
4. European research interest groupings	4. Monitoring RTD & EC actions
5. Regional technology plans	5. Coordinating RTD & EC actions

Source: A. Hingel – MONITOR-FAST PROGRAMME, CEC DG XII (1992).

general relevance in a developmental sense is the Regional Technology Plans (RTP) proposal.

RTP thinking absorbs the lessons of STRIDE (Science and Technology for Regional Innovation and Development in Europe) which is widely seen as having been only a modest success, mainly because initiatives were too piecemeal and too limited. It has now been realised that much more intra-regional networking must be activated across a range of firms, private and public institutions and existing programmes to make an impact upon innovative activity. However, research has shown, as noted, that while implanting wholly new innovation activities is extraordinarily difficult, developing them out of existing sectoral competences is less so. Good examples of this can be found in the German steel industry, where Ruhr-based firms spawned large numbers of innovative activities themselves, and in their suppliers, as they diversified into innovative technologies after the 1980s steel crisis. A similar phenomenon was observed in the Danish textile industry, as described by Kristensen (1992), and the old watch-making areas of Switzerland, and southwest Germany, which have become innovators in microelectionics.

The RTP idea involves, first the creation of an innovation network (or enhancement if it exists) composed of agencies, firms, research centres etc. Second it implies undertaking a review or audit of existing research competence and capability in relation to regional economic structure, skills, and global emergent technology trends. The third element concerns developing actions with associated monitoring and evaluation instruments. Finally, there are the implementing actions, as appropiate to different regional settings.

Further, RTP suggests that a point has finally been reached where the diversity and innovative potential of all parts of the Community are needed in order for Europe to be competitive with, in particular, Japan. Japanese production demands the full involvement of its employees as thinking, subjectively-engaged innovators, supervisors, fault-finders and so on. Therefore, a model of innovation is emerging where the resources of the whole EC need to be drawn upon to deal with, not local, but global problems of competition.

The competitively advantaged economies

In looking at achieving excellence for regional economies it is wise to focus on what is achievable within practical limits. Thus, regional and small-nation economic comparisons are more appropriate than, say, modelling on the Japanese economy with its scale and cultural, financial and governmental assets. For reasons of mix, we have chosen Denmark (small economy, innovative firms, few large indigenous corporations), Emilia-Romagna (weak regional institutions, many SMEs, no large firms), and Baden-Württemberg (strong *Land* Government, innovative SMEs, large indigenous corporations) to illustrate excellence in a relevant context at an appropriate scale. Because we have chosen to examine the role of Technology, R&D and Technology Transfer in the creation of economic excellence, these elements will receive most attention. Table II summarises some basic economic relativities.

Baden-Württemberg

This is one of Germany's strongest regional economies with, at its heart, the Mittlererneckar industrial region centred on Stuttgart, where Gross Domestic Product (GDP) per capita is 34% above the EC average of 100. Key employers are Automotive (237,000), Electronic (266,000) and

TABLE II
Economic indicators for advantaged economics

	Population % (EUR = 100)	Industrial employment %	GDP per inhabitant 1986–88 (EUR = 100)	Unemployment rate 1990 (EUR = 100)
Baden-Wüttemberg	2.9	47.0	119.9	35.4
Denmark	1.6	27.1	112.5	79.9
Emilia-Romagna	1.2	36.5	127.6	55.9

Source: European Commission (1991).

Mechanical (281,000) Engineering. Leading firms include Daimler-Benz, Porsche and Robert Bosch, all headquartered in the region, Audi, Alcatel-SEL, Sony, IBM and Hewlett-Packard. World-leader machine tool firms like Heidelberg, Trumpf and Traub are also based there.

The large and small firms (SMEs) of the region interact fruitfully. Many Mercedes, Audi and IBM supplier firms are present in Baden-Württemberg (BW). Helping the SME or *Mittelstand* sector keep innovative and the large firms to acquire basic research findings are a host of universities (9), polytechnics (39), basic and applied research institutes (44) and Steinbeis technology transfer centres (120). These, along with the thirteen Chambers of Industry and Commerce, and the trade and industry promotion and financing activities of the Business Associations and the Ministry of Economic Affairs and Technology, are the basis of BW's regional innovation system. To this should be added BW's much vaunted "dual system" of vocational training. In this, apprentices spend one third of their three-year's study in college, two-thirds at the workbench.

A good example of the way this network operates concerns the impact of "lean production"[2] upon *Mittelstand* SMEs (see, Morgan, Cooke and Price, 1992). Lean production is the key to the competitiveness of Japanese industry.

Japanese competition causes large firms to demand greater innovation from SMEs who supply them with components and services. However, in BW the business associations know that SMEs cannot afford R&D. In response the *Land* or regional Ministry of Economics approaches and appoints international consultants to investigate. The consultants' report recommends SME co-operation, but they fear loss of know-how. So the BW cabinet recommends an Applied Research Institute as third party R&D broker.

In exchange for accepting this solution, with an independent intermediary protecting the innovation knowledge of the SMEs, firms will receive government incentives towards the costs of establishing R&D functions. Not all supplier firms – even in the machinery industry where the pressure is severe – will join the initiative. Many of the non-joiners will become second or third tier suppliers, go under or become Japanese acquisitions.

Denmark

With a population of 5.1 million, approximately half that of Baden-Württemberg, it is not surprising that Denmark has a relative lack of both large, research-based firms and a government technology policy. Research by the European Commission shows that Denmark was slow to introduce microelectronics equipment and that when efforts were made to catch-up in the 1980s there were organizational inadequacies and skills shortages. However, Denmark is the EC's second most prosperous country in terms of GDP per head. Because of Denmark's small stature it can generate communication and interaction economies, especially in its system of SMEs.

Of key importance to this system are the support infrastructures for small business, the most important of these are: the Chambers of Commerce and Industry; Local and regional Technical and Special Technical Schools; Local and regional banks providing long-term loans for local SMEs; and the Danish Technological Institute with its 15 Technology Centres.

The Danish Technological Institute (DTI) is a privatized branch of the Ministry of Industry. It employs 1,200 technologists and others in developing, identifying and transferring generic technologies, largely to SMEs. Some 55% of DTI's contract income is from firms employing less than 50 people.

Recognizing that isolation from information and know-how was a handicap to SMEs, DTI in 1989 established a "Network Programme" which channeled government support to firms willing to co-operate in certain business activities. In one small town in Jutland, the following case-history is instructive.

Seven small furniture makers found local markets shrinking. With the aid of a DTI broker they took advantage of the Network Programme. Their discussions led to them agreeing to create a trading company. Through the trading company, they divided up key tasks, so that, for example, design for all firms is done by two designers. Each firm specialises in a particular production phase and the company now exports high-quality furniture to the EC and beyond.

By 1992, 175 networks had been created, in which 42% of the firms had increased turnover per

year by 4% or more, and one in five showed increases of 10% or more. Of key importance to the success of this programme was the appointment by DTI of "Network Brokers". These are local professionals, lawyers, consultants or engineers whose job it is to create networks of firms, colleges, local authorities, enterprise agencies and so on. These networks then bid for grants from technology programmes aimed at product and process innovation, quality improvement, product differentiation, and, very importantly, design, which is seen as a key selling point. These networks maintain the philosophy that "The Competitive Advantage of Regions is Achieved through the Competitive Advantage of Firms".

Emilia-Romagna

This northern region of Italy, centred on Bologna, is home to numerous examples of "industrial districts". Bologna itself is a major centre of machinery-production, Carpi specialises in clothing, Sassuolo in ceramics and Modena in motorcycles (Ducati) and luxury cars (Ferrari, Maserati, Lamborghini). Apart from these famous names, Emilia-Romagna (ER) has few large firms but a large number of SMEs (245,000–90,000 in manufacturing – employing less than 50 in 1988).

The industrial SMEs tend to cluster in districts which, because of the polycentric urban system of the region, are spread out at the foot of the Apennine mountains. As in other dynamic SME-based economies ER is rich in business support infrastructure. The main institutions and their functions are:

Artisans Associations – accounting, payroll and income tax returns, training, financial advice, technology and premises; Local and Regional Banks – small loans, long-term loans, community-based referral, etc; Chambers of Commerce – information, exports, trade fairs, technological and financial advice, marketing; and Regional Government -regional development agency (ERVET) and local Innovation Centres.

The regional government, the Chambers of Commerce, banks and business associations have shares in ERVET (Ente Regionale per la Valorizzazione Economia del Territorio) which in turn runs nine dedicated Innovation Centres. These provide "real services" (not financial grants or loans) to SMEs in specific industries. Services include; research, promotion, certification, technological consultancy and training.

As an example of the innovative capacity of CITER (Centro Informazione Tessile Emilia Romagna) the clothing innovation centre, the following is illustrative. Third World firms are increasingly copying Carpi clothing designs, taking market share. The Artisans Association tells ERVET of loss of Carpi firms' competitive design advantage. ERVET asks the Italian energy research institute (ENEA) to work with CITER. ENEA and CITER develop a new CAD-CAM design system for SMEs. The SMEs access CAD-CAM; time-to-market is reduced tenfold and market share is recovered. The time taken to solve this problem was under one year. Let us now look at the approach being taken in less accomplished regional systems.

The learning economies

If firms in networks make 4% a year more than those outside them, why doesn't everyone join in? We maintain that there are three primary reasons for not adopting this approach. In the first instance, firms are protective of their know-how. It is after all, the source of their competitive advantage. Second, firms are fearful of divulging pricing information which can easily be undercut by a competitor in the know. Finally, firms, especially SMEs, cannot reap advantage without the existence of a public support infrastructure, at least in the short term. This is because of market failure, particularly pronounced in the innovation field with its lengthy lead times and variable rate of return on investment.

The first two objections can never ultimately be overcome because know-how and price are two key areas where market transactions eventually triumph over network relations in a competitive arena. The third point has been recognised as a fact even in the home of "rugged individualism", the U.S.A., where learning from European experience has been developing apace especially in Pennsylvania. After looking at this American case, we will return to Europe to explore the three experiences of older industrial regions (Nord-Pas de Calais in France, Wales, U.K., and the Basque Country in Spain) and the widely-quoted case of

Valencia region in Spain, which has successfully applied innovation practices learnt from Denmark, Emilia-Romagna and Baden-Württemberg, in its quest for economic excellence.

Pennsylvania

This state lost large numbers of jobs in the 1980s; 50,000 disappeared from the clothing industry and 15,000 from the foundry industry, for example, which added to the strife already caused by the closure of Pittsburgh's steel mills in the 1970s and 1980s which cost 100,000 jobs. Typically, in such a context, state and local governments took the lead in seeking economic regeneration, including trying to stimulate innovation in the regional economy.

Pennsylvania's economic strategy moved through three phases during this period of extended industrial and employment crisis. Phase one includes the period up to 1975 when economic development policy was aimed at providing traditional services (information, business advice, "signposting") to help individual firms innovate. This was a clear failure. Next, during the period of 1975–1988 policy changed as the crisis deepened. The strategy became one of helping firms and institutions (trade associations, colleges, unions, local government) in localities to define collectively the services they need. To manage this the state set up the Ben Franklin Partnership (BFP) in 1982 as a development bank to fund joint R&D projects between firms and universities. The assumption was that innovation required finance and technology and the state provided the means to access both. Key to this was BFP's extension service of nine Industrial Resource Centres. These were needed because it quickly became clear that bank-finance and technology were not enough. Firms (mostly SMEs) needed management, marketing, technical and worker training services as well. Above all, SMEs were discovering that innovating in mature industries was more successful than aiming for breakthrough technologies.

Finally, after 1988, the new phase built on this experience. BFP concluded that the most successful element of its work was helping networks of local firms and institutions to help themselves. To support this the Manufacturing Innovation Networks (MAIN) project was set up in 1989. MAIN was learnt from Europe, Denmark in particular. It works by inviting bids for strategic regeneration projects up to a maximum of $100,000 for one year. Only networks need apply and only four are selected. The first winners included: Pittsburgh foundries, Lehigh Valley clothing; Lake Erie plastic and Philadelphia/Pittsburgh tool-and-die networks. The networks co-operate around any one of four special Technology Centres who protect network-members' know-how, they also have access to specially skilled workers from any of 45 educational centres of excellence.

Although it is too early to judge the significance of these efforts, it is worth noting the move up-market to higher value-added production by the Pittsburgh foundries. Of 45 in the locality, between a third and a half were selling design, engineering, drafting, welding and machining services as well as, in many cases, just-in-time delivery. Moreover, some were engaging in successful joint-bidding for contracts and co-operating in provision of complementary services. The region was being advertised as a "Foundry Centre", something that had not happened before.

Nord-pas de Calais

This region of northern France, centred upon Lille, and close to the Belgian border, has suffered very badly from the loss of its coal industry and the severe decline in employment in the textiles and steel-making industries. Table III demonsrates relativities in economic indicators for this and three other less-favoured European regions, and should be compared with Table II above.

To combat the loss of 75,000 textile jobs in the 1980s, Nord-Pas de Calais (NPC) definitively adopted a regional technology strategy centred upon the Technopole idea at Villeneuve d'Ascq Scientific City. This classically French growth complex is a new town with 60,000 inhabitants, 95,000 students in five universities, eighteen engineering schools and 340 research laboratories employing 4,000 researchers. Major national research institutes, which include the Pasteur Institute, CNRS (natural and social science research council) as well as three others, are joined, in the region, by three CRITTs (Regional Centres of Innovation and Technology Transfer)

TABLE III
Economic indicators for less-favoured regions

	Population % (EUR = 100)	Industrial employment %	GDP per inhabitant 1986–88 (EUR = 100)	Unemployment rate 1990 (EUR = 100)
Nord-Pas de Calais	1.2	36.0	87.8	138.6
Wales	0.9	33.8	87.8	95.6
Basque Country	0.7	41.6	89.0	222.6
Valencia Region	1.2	36.3	75.3	174.3

Source: European Commission (1991).

and numerous incubator centres for high technology start-ups.

However, the judgement is that innovative cross-fertilization is too weak. Two phases of development in the strategy explain this. First, during 1983–89 there was a strong belief in the *natural* synergies that flow from geographical clustering. This was undermined because there were too many actors, a few privileged firms got the attention, marketing was poor and technology transfer failed. As a consequence, during the period 1989–93, a networking strategy was adopted with an *animateur* agency charged with easing the interactive processes between firms and researchers. The pole in itself had been recognised as being insufficient to foster innovation.

Firms in the region are more hopeful now but criticise the lack of "people-skills" amongst the engineering community. Marketing has improved but funding criteria are still too rigid and, not surprisingly, many advanced technology start-up SMEs have such specialised technological requirements that the local pole cannot meet them. In essence the strategy was too big, too isolated and inadequately managed. Networking is perceived as the solution to these problems (see, especially, Cooke, 1993).

Wales

Wales has experienced significant economic restructuring since 1980. The two main traditional industries of coal and steel have reduced jobs available by some 60,000 and while the steel industry is now competitive, the coal industry has virtually disappeared. Wales is fortunate, in the U.K. context, in having both a regional department of government, the Welsh Office, and an economic promotion body, the Welsh Development Agency, the main tasks of which have been to modernize the Welsh economy. While there remain pockets of severe unemployment in the former coalfield areas, these organizations have been remarkably successful in helping to introduce new businesses, many from overseas, and to develop innovative business practices amongst indigenous firms. A recent policy development has been to stimulate partnership between regional and local governments, and networking between firms, supported by innovation policies and functions from government bodies.

At present, a number of these initiatives to boost innovation are in place and, though there is not yet a clear Regional Innovation Strategy, this may develop through the assistance of the EC RETAS (now RTP) programme. One key survey that has been conducted concerns the identification of the scale of innovative activity within Wales. This shows the following results. First, Gross Expenditure on R&D as a percentage of GDP (1991) in Wales was 1.1%. This is mostly (0.8%) industry expenditure. Wales scores better than, for example, Denmark (0.8%) and Spain (0.6%) but less than half the rate for Germany and Japan (2.9%). Second, in Wales, most innovation synergies are *between firms*, more than between firms and universities. Small and medium enterprises are more active than the U.K. average in winning EC and U.K. innovation projects. Finally, there is an increasing demand from both large and smaller firms for intermediary Innovation Centres that can provide services in technology assessment, information and applications.

In response to this situation numerous initiatives have been taken, especially by the Welsh Development Agency (WDA) to assist innovation:

(i) a great success has been the WDA and Welsh Office foreign direct investment programme which has attracted up to 15% of all the U.K. *inward investment* since 1980. The total amount of inward investment and reinvestment in 1992 was over £1 billion. Many of these firms are themselves innovative.

(ii) now, in order to balance this success a Supplier Development Programme, which links "clubs" of medium-sized firms vertically to large firms in a supply-chain, has been established.

(iii) to help to improve the skills of workers and management in supplier firms, Innovative Training initiatives, aimed at improving the quality of products and processes, are in place. These are managed in partnership between WDA, Training and Enterprise Councils, Enterprise Agencies and Higher Education Institutes.

(iv) Technology and Innovation Centres where new start-up firms are housed or applied technology services are supplied to firms have been set up in six locations. An EC Relay Centre, enabling firms to exploit EC science and technology programme results, links to these centres.

(v) WDA manages Eurolink, a programme linking innovative small firms in Wales to firms in partner regions such as Baden-Württemberg, Lombardy, Catalonia, and Rhône-Alpes. These firms exchange technologies and marketing networks.

The next step, soon to be taken, is to link all of these initiatives together in an RTP Innovation Network which enables firms in any location or industry to be put in immediate contact with the precise business support service they require.

The Basque and Valencia regions

These two represent an interesting contrast because, although they started out with similar kinds of innovation institution, local divergences have resulted in different policy avenues being pursued. The Basque Country has a better GDP per capita but a worse unemployment index than Valencia because it is an older industrial region (steel and shipbuilding) in decline, while Valencia is an up-and-coming consumer industry economy.

In response to its problems of industrial crisis, the Basque regional government devised a technology strategy which established, first, R&D support funding to firms and to 5 Technology Centres; second, SPRI, a regional technology transfer agency; and third, a Technology Park in a rural, campus setting near Bilbao.

While the Technology Park (£100 million public investment) has begun attracting innovative firms, mostly from the region, it is the R&D support, managed by SPRI (Sociedad Para La Promocion y la Reconversion Industrial), that has yielded the most impressive results. In ten years, Basque R&D expenditure moved from 0.1% of GDP to 1.4%, equivalent to Italy by 1989. Five key Technological Centres, employing between one to two hundred scientists and support staff, are responsible for this. They specialise in new materials, factory automation, information technology, machine-tools and energy technologies. Each works with a "club" of associate SMEs and transfers technology on a contractual basis. Subsidy to client and supplier is about 30% of the market rate. The centres are well-integrated into EC science and technology programmes so that best practice is quickly diffused into local firms. Special attention has been devoted to automotive components firms and machine-tool manufacturers. Some of the latter have grown into major competitors to German companies at the cheaper end of the market and, overall, while there are still problems of receptivity towards innovation by many SMEs, leading firms have been able to survive and some to do well in increasingly difficult and competitive international markets (Cooke and Morgan, 1992).

Like the Basque government, the Valencia region has also adopted a Technology Centres approach to its innovation strategy and has created an agency, IMPIVA, to manage them. Moreover a Science and Technology Park has been built. Among the industries in Valencia that receive special support are ceramics, footwear, textiles and science-based activities. Each of these is located, as in Emilia-Romagna, in industrial districts. Because of this, Valenica formed a partnership with ER to model its strategy on theirs. More importantly, the Valencians visited Denmark

and borrowed the Danish idea of Network Brokerage.

The Network Brokerage idea builds on the other elements of the innovation strategy. There are three networks. The first is the Inner Network: composed of IMPIVA, the Technological Centres, 5 Business Innovation Centres and the Technology Park. Second comes the Outer Network: 4 Regional Universities, Chambers of Commerce, trades unions, design and training agencies. Finally there are the Spanish and EC Networks.

In addition Network Brokers are drawn from the professions (consultants, engineers, etc.) and link networks of firms in particular industries to any or all of these network players. Firms can thus co-operate, as in Denmark, on distribution, sales and promotion, exports, joint purchasing and product and process innovations. Valencian SMEs are, however, overly-dependent on support from what is, nevertheless, an expanding public support infrastructure. Even the Emilians are impressed by the excellence of Valencian ceramics but the shoe industry is surviving rather than booming.

Mechanisms for realising the innovation network

There are a number of key conditions that have to be present to mobilise the necessary parts of an innovation network. We have identified these as the summarised as the "4 Is":

Identification
It is vital that the base upon which an innovation network is to be constructed has a high degree of self-identification, political coherence, policy-commitment and capacity to deliver. Euro-regions with a high degree of administrative (e.g., German *Länder*) or politico-cultural basis of identity (e.g., Basque Country) work well in this respect. Wales is also easily identifable, in addition possessing many of the Wales-wide government agencies capable of assisting development within the region.

Intelligence
In its twin senses of information and learning capacity, this condition is a key source of advantage. "Intelligent regions" such as Emilia-Romagna or Baden-Württemberg have:

- Good antennae;
- Quality information;
- Capacity to self monitor and evaluate;
- Learning Disposition;
- Desire to implement lessons learnt.

Institutions
An innovation architecture consists of institutions and the people in them. Innovation is an interactive process. The denser the mass of institutions the greater the likelihood that business will gain access to the intelligence for innovation. An element of "redundancy" (i.e., fail-safe "network circuitry") is common in innovative regions. Key institutions are, for example; strong Chambers of Commerce, Business Associations, Innovation Centres, Training Agencies, Development Agencies, Higher Education Institutions and Firms themselves. In accomplished regions, the public sector institutions tend to be in the background, in weaker ones they are in the foreground.

Integration
The key to a successful innovation architecture is that these institutions form a network not a "jungle". In other words they must organize a division of responsibilities between each other so that a firm or customer approaching any point on the network can be successfully and accurately relayed to the optimum information point on (or beyond) the regional network. The integration of a network must, for the sake of efficiency, be animated or facilitated by a primus inter pares such as major businesses or a development agency, chamber of commerce (where it is sufficiently powerful) and so on.

Steps towards achieving the "4 is"

Most regional administrations in the EC do not enjoy the "4 I" conditions. They are present to a greater or lesser extent in the country of Denmark and regions such as some German *Länder* (e.g., Baden-Württemberg) the French region of Rhône-Alpes, Lombardy and Emilia-Romagna in Italy, Flanders in Belgium and, in limited ways, Catalonia in Spain.

There are five steps that are necessary to achieve the geographic dimensions as described above:

1. Stakeholders;
2. Strategy;
3. Standards;
4. Sectors;
5. Skills.

Stakeholders are the source of Identification. It is not enough to have verbal support to go ahead; there must be real commitment of financial and human resources. Thus the first task of the animateur is to identify and bring together in a network those organizations, institutions and firms which are to be the stakeholders in the innovation architecture. These will include:

- Large firms;
- Small and medium enterprises;
- Higher education institutes;
- Training organizations;
- Economic development agency;
- Regional government;
- Chambers of commerce.

These and others will exercise both partnership and guidance of the network. If stakeholding is to be meaningful stakes will be mainly financial (but could be in kind, e.g., equipment, secondments, property).

The Aim should be to make the Innovation Network as close as possible to being self-financing.

Network centres could be given a 5-year target to achieve this, with public subsidy at the outset tapered to, say, 30% by end year 3 and zero at end year 5. Supplementing the subsidy would be shareholdings which the private-sector could take in the Network organization. Over time, the Network centres would sell services at market rates to cover costs.

So what would the Stakeholders have shares in? To fulfil the "Intelligence" condition, the Innovation Network must be driven by a Regional Technology Strategy. This involves two dimensions. First is Regional Technology Audit: a comprehensive review of existing Innovation resources. Comparison of levels of Government and Business Expenditure on R&D as % of GDP with targets to be reached in 3, 5, 10 . . . *n* years, etc. Identification of innovative large firms and SMEs; identification of innovative skills-providers, colleges, etc. Emergent technologies in firms and universities; linkages with overseas firms in R&D. Involvement in EC R&D schemes; awards of national government innovation incentives, etc. Second are Lines of Action to creating further advantage on the basis of the audit. Animated by the Stakeholder Network the primary aim would be the building of local capacities for improvement. The fundamental philosophy should be "continuous improvement" towards and beyond benchmarks. Monitoring, evaluation and measurement instruments need to be designed at this stage and consideration given to the all-important factor of innovation, delivery mechanisms.

The Regional Technology Strategy must be suffused with the "continuous improvement of standards" (Japanese: KAIZEN) philosophy. This means, first, far-reaching but focused intelligence gathering about best practice in other, appropriate comparator settings. Second, establishing detailed profiles of research and technologically-related expenditure and – crucially – quality of outputs from R&D institutions; comparing with best-practice. Third, setting targets for improvements in quality-assurance (e.g., ISO 9000) amongst domestic and foreign-owned business, support institutions, etc. Fourth, raising the number of Preferred Supplier Status or First Tier Supplier firms to foreign and domestic Original Equipment Manufacturers (OEMs).

The tried and tested approach to achieving the above is to adopt an industry-sector focus. For example, in the Basque case, the dramatic improvement in R&D performance was achieved by focusing support principally on the machine-tool and automotive components sectors. A sectoral focus has the following benefits:

(i) simplifies the management of the innovation support architecture;
(ii) gives further identification to the strategy;
(iii) focuses commitment from the stakeholders;
(iv) clarifies the standards of best practice being sought;
(v) concentrates the impact of the delivery mechanisms.

A sector focus suggests that, on the key question of delivery mechanisms, a hub-and-spoke system in which, for example, sector-specific innovation-support centres with outreach points can maximise accessibility of centres to firms. Thus, in the

Danish case two main DTI centres link to 15 outreach centres, some but not all of which are sector-specific. The Basque Regional Technology Centres are broadly sector specific but have only limited outreach functions. One reason why centres may be inadequate is that they work best in industrial clusters (e.g., in the Emilia-Romagna context). Most industry is diffused rather than clustered on Italian lines. However, a network arrangement is flexible enough to allow services to be delivered on a more diffused basis.

There are crucial skill-considerations involved in adopting an Innovation Network Architecture. First, emphasis must be given to Policy Skills – an Innovative Network Architecture is neither a State nor a Market institution, at least at the beginning. Thus neither an Administration nor a Competition model of policy implementation is called for, but something in-between. The key elements of networking are outlined in (ii) below; however, questions regarding the identity of:

a) the animateur/facilitator,
b) the appointees of the Regional Technology Strategy group,
c) those to whom these are accountable,
d) those who appoint Innovation Centre staff,
e) to whom they are accountable,

need to be clarified. In general, an *entité-mixte* with a public-private board would seem most appropriate, but a longer term aim to establish a private firm to manage the Innovation Network, especially Innovation Centres, should not be ruled out.

Second, attention must be paid to Networking Skills – some people have these, most do not. Generally, those who will work in the Innovation Network require training. Networking involves:

a) Reciprocity – an exchange relationship;
b) Trust – risking the reliability of others;
c) Learning – preparedness to change;
d) Partnership – preferential reciprocity;
e) Decentralism – very flat hierarchy.

Such practices are unusual in the regions. They must be learned.

Third, and of paramount importance, are Innovation Skills – Whichever personnel occupy whatever roles in the Network "hearts" – the Innovation Centres – they must:

a) have the five key networking skills;
b) be psychologically open, enthusiastic, "fanatical;"
c) combine technology/business management/and marketing skills;
d) must be able to convince firms to become members/associates/subscribers/supporters/users of the network, its hubs and spokes;
e) must themselves be innovative, initiative-taking;
f) must be well-networked within their country and beyond to innovation centres and systems in EU, Japan and North America.

Conclusions

It is clear from Figure 1 that the following are crucial elements of the Innovative Network Architecture.

Conditions	Steps
INTELLIGENCE	Stakeholders
INSTITUTIONS	Strategy
	Skills

This set of proposals rests on ideas that could, based on the experience of other EC regions, make a significant contribution to the innovative potential of industries in less advanced regions. The main issues are not whether this should be done, but how soon, and what financial resources are needed to set it up. More research is needed into the market demand and technology capability of firms and Higher Education Institutions in development regions. More thinking is needed about the cost of doing this. However, the likelihood is that an Innovation Network strategy will not be expensive. The largest Basque technology centres have an annual turnover of ECU 6 million to ECU 8 million. Two Centres at a lesser stage of development might warrant an investment of ECU 5 million each over five years, arranged to boost subsidy at the beginning but on the contractual understanding that subsidy should taper off by the end of the five year start-up and establishment period. Thereafter the Innovation Centres would earn both public and private contracts through normal bidding procedures. EC financing could be made available to part-fund such an

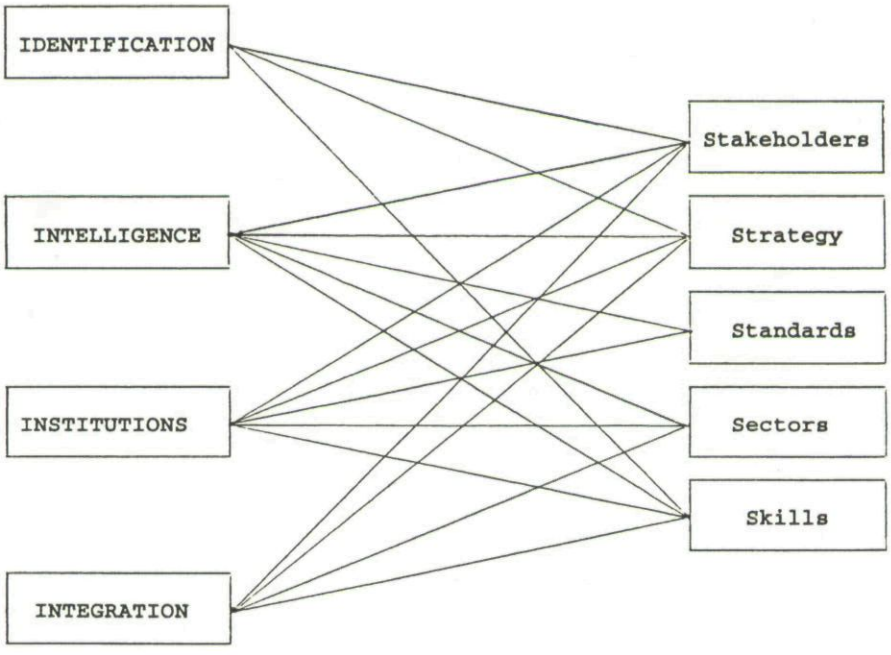

Fig. 1. Building an innovation network architecture.

initative but the aim should be to set up the Innovation Centres, probably one at a time, through a public-private partnership the performance of which can itself be monitored and from which lessons to improve future practice can continue to be learned.

Notes

[1] It is also worth noting, in passing, that many major innovation centres are outside Europe. On this see, for example, Sternberg's contribution to this volume.

[2] Lean production is superior to mass production in that a product (notably an automobile) is produced in twice the time for half the cost at ten times the quality (on this, see Womack and Jones, 1994).

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