The promotion of innovation in regional policy: proposals for a regional innovation strategy

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This paper argues that given the correlation of innovation and R&TD efforts with regional economic development, closing the inter-regional 'technology gap' in the European Union, which risks further widening, becomes a pre-condition for reducing the 'cohesion gap', which is the primary objective of regional policy. Therefore regional policy should increasingly concentrate its efforts in the promotion of innovation if it is to be successful in creating the conditions for a sustained (and sustainable) economic development process in less favoured regions. Hitherto, support for the promotion of Innovation in the less developed regions has been generally inadequate in quantity and quality to meet their economic development needs and it has not been adapted to the specific characteristics of the process of Innovation in different regional contexts. The inadequate intensity of the Innovation effort by the public sector and particularly by the private sector, and its poor adaptation to the specific needs and conditions in the less developed regions (due to a lack of understanding of the innovation process at the regional level) helps increase the 'technology gap' between regions and tends to perpetuate or even increase the 'cohesion gap'. The author argues that one practical way to approach this problem may be to encourage regions to develop regional Innovation strategies. These strategies should aim at promoting public/private and inter-firm cooperation and creating the institutional conditions (consensus among the key regional players) for a more efficient use of scarce public and private resources for the promotion of innovation (bigger and better spending in this field through regional policy).

Keywords: innovation; regional development; industrial policy; regional policy; strategies; regional technology policy; innovation models.

1. Introduction

Economic thinking in Regional Policy has to face the theoretical challenges stemming from an accelerated integration, over barely two decades, of the analysis of innovation and technological change into the central body of the doctrine.

One can identify three such challenges: first, there is the need to explore new theoretical models, building on those that have already been progressively adapted and improved in the literature, namely the different interpretations of the 'linear' model, the 'Chain-Link' model (Kline and Rosenberg 1986: 289) and the 'Systems' model (Soete and Arundel 1993: 29), able to explain better the Innovation process by integrating the regional variable, and which could be used in an operational way by those responsible for regional economic planning. That is, the need to better understand the economics of Innovation in a particular regional setting through a theoretical model that can be translated operationally, and therefore can contribute to improved policy-making in this field.

There are a number of reasons why this is particularly important today in Europe. The process of economic and monetary integration is progressively homogenizing not only the costs of factors of production, and therefore diminishing the relevance of traditional comparative advantages (e.g. low labour costs in less favoured regions – LFRs), but also it is reducing the margin of manoeuvre of public administrations in their ability to influence and manage the economy (e.g. demand management policies and monetary policy in particular) (Robson 1984: 119). In this situation, the necessary trend towards convergence in income and productivity in order to reduce the 'cohesion gap' among regions depends, more and more, on the generation of competitive advantages through the valorization and upgrading of regional endogenous potential. Technological innovation is probably the single most important factor that may contribute more to the 'creation' of the above mentioned regional competitive advantages.

In order to exploit these variables appropriately it is first necessary to understand better what are the precise mechanisms through which the innovation process works, including its diffusion, across and within regions. Moreover, it is likely that in the future, the more intensive use of supply side policies, – which is where the public sector can manoeuvre most – is going to have an increasingly regional character within the European Union.

Second, in parallel to the above mentioned theoretical efforts in modelling, it is important to do statistical research that can develop internationally comparable regional indicators that may allow us to increase the detailed knowledge about the different regional contexts in this field. In this way one will also be in a position to assess the utility and relevance of the above mentioned theoretical models. In the absence of this complementary effort one risks elaborating models whose ambitions for universal explanations would not respond to the specific characteristics of economic realities in different regions, less favoured ones in particular. It is also essential that research efforts in this field are based on an intimate knowledge of the regional socio-economic, political and institutional realities in each case.

This drives us to the last, but not least, of the challenges: striking a balance between doing and thinking, or more specifically between those who are fully committed to 'thinking' and constructing models about innovation and regional development and those who are responsible for actually conceiving and carrying out innovation promotion policies in the regions. Today the distance between the two is considerable. On the one hand, the former risk building excessively theoretical models with little operational translation. On the other hand, the absence of sound theoretical reflection by the latter compromises the nature of their regional policy diagnosis of the situation and strategic recommendations. The two groups work and reason largely in isolation from each other for the moment.

The sections that follow try to address some of these challenges in the particular context of regional policy in LFRs. It tries to be an 'action oriented' reflection looking for operational recommendations to planners responsible for regional policy in underdeveloped regions.

2. The policy challenge: the inter-regional technology gap

There is considerable empirical evidence that effort in innovation (including associated efforts in research and technological development, R&TD) and the capacity of regional economies to adapt to technological change correlates positively (Rothwell and Zegveld 1981: 29) with economic development (Quintanilla 1992: 46). It has been associated with increases in growth rates (Solow 1957), exports and trade

(OCDE 1982), productivity (Amable and Boyer 1992: 45), income and output (Freeman 1982: 198) and business profits (Goddard *et al.*, 1987: 10) in the economic literature.

This paper will argue that the differences noted in the intensity of the innovation effort, the speed of adoption (Goddard *et al.* 1985: 217) and/or creation of technology and the appearance of new firms (Aydalot 1986: 105) and sectors (Hall 1987: 5) that make intensive use of innovation depend in turn on the varying socio-economic conditions that have a territorial and geographical dimension.

Statistical analysis confirms that there is a 'technology gap' twice as great as the so-called 'cohesion gap' (measured in terms of inter-regional differences in income, productivity and employment) between the developed and the less developed regions of the European Union (as shown in Table 1). Moreover, there are also factors that are tending to enlarge this gap (Ekonomu 1992): the increasingly scientific nature of technology, the mutual strengthening of the R&D and education systems of the leading countries, the reduction in the life cycle of certain technologies and the importance of quality infrastructure.

In this paper the three main characteristics of the gap that seem to be particularly relevant *vis-à-vis* public policy efforts in the field of innovation promotion at the regional level will be discussed. First, the 'technology gap' is a particular cause for concern with regard to the human resources for innovation, since human capital is increasingly a source of the dynamic comparative advantages that govern the potential for Innovation in the regions in the long term. More and more so in an increasingly knowledge-based economy (Castells 1987: 45, Capellin 1992: 5, Chabbal 1992) in which the only real capital is human capital. At present, the differential between advanced and less developed regions is one to six and growing in terms of research staff as narrowly defined, mainly by reference to research workers in firms. In 1988 (OCDE 1992a), for example, the Netherlands had more than twice the number of R&TD scientists and engineers working in Greece and Portugal taken together. Germany, with approximately the same number of R&TD personnel per thousand labour force as Japan, had more than three times the Spanish rate and about six times the Greek and Portuguese rates.

Second, the existing schemes for public assistance in Europe are tending to increase the technology gap between the most advanced countries of the Union and the less developed regions. In the case of public assistance for innovation (R&D), the most developed countries in the Union provide over ten times more aid per person employed than the less developed regions, particularly through horizontal measures (mainly directed at small firms), which offset the tendency of firms to under-invest in innovation (Table 2). That is, advanced regions normally have bigger, more sophisticated and better adapted public support schemes for the promotion of innovation than less favoured regions.

Third, there is a geographical concentration in the advanced regions of the Union of a few centres of R&D 'excellence' or 'islands of innovation' (Hilpert 1992) comprising firms making intensive use of technology and R&D laboratories that co-operate almost exclusively among themselves. Those engaged in innovation in the less developed regions scarcely participate in these networks of co-operation (firms and R&TD centres from LFRs participate only in 5 to 8% of international co-operation networks of R&D 'excellence') and encounter severe problems in forming links with external sources and technological partners whether at international level or inter-regionally within their own countries. Moreover, those actors from LFRs participating in

Table 1. Technology gap in Europe.

	Belgium	*Denmark*	*Germany*	*France*	*Italy*	*Holland*	*U.K.*	*Eur 7*	*EurO1(*)*	*Greece*	*Spain*	*Portugal*	*Ireland*
Basic research													
GERD M$	2,060	1,058	24,548	17,441	9,157	4,263	17,002	75,529	3,474	251	2,647	328	248
GERD/inhabitants, ppp$	209	206	400	312	159	289	298	268	49	25	68	32	70
GERD as % PIB	1.61	1.48	2.83	2.29	1.23	2.26	2.20	1.99	0.62	0.37	0.73	0.50	0.87
Public financing for R&D in % of total Budget	1.40	2.28	4.11	6.91	1.85	2.50	2.83	3.13	1.19	0.60	2.19	0.98	0.98
% of GERD in higher education (%)	18.20	24.40	14.60	14.80	20.30	20.70	15.30	18.33	24.33	24.20	19.20	34.00	19.90
HERD M$	374	258	3.537	2.573	1.861	883	2.559	12.045	182.75	60.60	509.30	111.50	49.60
HERD as % PIB	0.29	0.36	0.41	0.34	0.25	0.47	0.33	0.35	0.14	0.09	0.14	0.17	0.17
R$D personnel FTE (*n*)	34,985	24,328	426,189	257,505	140,469	64,870	271,800	1,220,146	92,707	9,387	63,154	11,463	8,703
R&D personnel/1000 inhibitants	9.10	8.50	14.30	11.90	5.80	9.90	10.00	11.58	3.80	2.40	3.80	2.40	6.60
R&D personnel FTE in higher education and government as % over total R&D personnel (%)	36.99	41.47	29.86	41.82	53.78	48.76	33.54	40.89	70.55	80.72	58.74	75.75	66.99
RSE FTE (*n*)	16,667	10,369	165,616	115,163	74,833	24,150	127,413	534,211	47,929	5,461	31,168	5,000	6,300
RSE FTE as % of total R&D personnel FTE (%)	47.64	42.62	38.86	44.72	53.27	37.23	46.88	44.64	55.88	58.18	49.35	43.62	72.39
Applied research and technological development													
% of GERD by private sector (%)	73.60	55.30	72.40	59.50	57.80	60.00	66.60	63.60	41.60	28.20	56.80	24.60	56.80
BERD M$	1,515	585	17,771	10,373	5,294	2,559	11,321	49,418	1,795	71	1,503	81	141
BERD as % PIB	1.18	0.82	2.05	1.36	0.71	1.36	1.46	1.28	0.28	0.10	0.41	0.12	0.49
% of BERD financed by industry (%)	94.80	83.60	86.30	69.90	74.50	83.70	71.00	80.54	85.28	79.40	80.70	95.50	85.50
R&D personnel FTE in the private sector as % active population (%)	0.85	0.73	1.52	0.93	0.31	0.74	0.92	0.86	0.665	0.47	0.70	0.37	1.12
RSE FTE in the private sector (*n*)	8,533	4,241	107,113	51,842	29,905	10,280	88,000	299,914	11,104	741	8,550	474	1,339
RSE FTE in the private sector as % of total R&D personnel	24.39	17.43	25.13	20.13	21.29	15.85	32.38	22.37	10.24	7.89	13.54	4.14	15.39
Number of business and innovation centres (BICs)	4		3	11	14	3	6	37	28	4	15	5	4
Number of research institutes	78	107	1021	1321	924	1259	668	5378	1646	352	1138	60	96
Number of science parks and incubators		15		76	50	5	50	70	266	18	5	10	3

Table 1. Technology gap in Europe. (continued)

	Belgium	*Denmark*	*Germany*	*France*	*Italy*	*Holland*	*U.K.*	*Eur 7*	*EurO1(*)*	*Greece*	*Spain*	*Portugal*	*Ireland*
Innovation													
Domestic patent applications (*n*)	857	1,197	32,575	12,587		2,585	20,692	70,493	2,998	376	1,841	54	727
Inventiveness coefficient	0.90	2.30	5.30	2.30		1.80	3.60	2.70	1	0.40	0.50	0.10	2.10
Technology balance of payment receipts over payments (%)	0.70		0.84	0.80	0.54	0.54	0.92	0.72	0.12		0.13	0.11	
Productivity in industry (000s Ecus/worker)	39.10	36.50	35.40	37.90	36.80	42	33.40	37.30	29.77	13.10	28.90		47.30

Sources: OCDE (1992a) CEC-DG XII (1992), Eurostat (1993) and Visa database (1993).
R&D personnel refer to 1989. Some figures are taken to coincide with those available at the nearest year.
Definitions used follow the OCDE 'Frascati Manual' (OCDE 1992c).
GERD: Gross expenditure in R&D; HERD: Higher education expenditure in R&D; FTE: Full time equivalent; RSE: Researchers, scientists and engineers; BERD: Businesses expenditure in R&D.
Inventiveness coefficient: domestic patent applications/10,000 inhabitants.
Productivity: value added at factors cost in 1985 prices/number of workers in the industrial sector.
Data on BICs come from EC sources (CEC 1993b).
Data on research institutes come from CEC-DG XII sources (ATLAS Data Base) and refer to 1993.

Table 2. State aid for innovation in the European Community – annual average, 1988–90.

	Total Employment (at the place of work) (1000)	*Manufacturing NACE-CLIO 30 Employment (at the place of work) (1000)*	*Overall state aid in MECU*	*Overall state aid to manufacturing in MECU*	*Overall state aid in ECU per person employed*	*Aid to manufacturing in ECU per person employed in this sector*	*A1*	*A2*	*B1*	*C1*	*C2*	*Total aid to innovation R&D in MECU*	*Aid to innovation/ R&D in ECU per person employed*	*Aid to innovation/ R&D in ECU per person employed in manufacturing*	*Index (Eur 12 = 100)*
	1988	1988		(1989 prices)											
Belgium	3653	724	3838	1211	1051	1673	79	70	–	6	–	155	42.56	215	156
Denmark	2605	524	1067	333	410	635	100	12		5	–	117	44.81	223	162
Germany	27,261	8357	25,758	7865	945	941	696	224		18	24	962	35.29	115	83
Greece	3779		1477	1072	391	1502*	12			0	–	12	3.12	15	11
Spain	12,205	2633	6000	2499	492	949	96			120	–	216	17.74	82	60
France	21,656	4440	16,023	6106	740	1375	474	316		236	0	1026	47.37	231	168
Ireland	1091	212	614	368	563	1736	14	–				14	12.48	64	47
Italy	23,073	5061	22,717	11,027	985	2179	294	–		146		440	19.08	873	63
Luxembourg	175	37	249	48	1421	1297	3	–		0		4	20.95	99	72
Netherlands	4820	913	2572	1225	534	1342	391	–		39		429	89.06	470	341
Portugal	3649	802	902	616	247	768	6	–	0	1		7	1.90	9	6
UK	25,614	5511	8152	3133	318	568	245	–		–		245	9.57	44	32
EUR 12	129,622	29,214	89,369	35,503	689	1215	2409	622	0	571	24	3627	27.98	138	100

Source: CEC 1992.
*Taken from SEC (92) 1384/2 (CEC 1992).
Per capita figures are estimates calculated by CEC DG XVI services.
A1 and A2 are aids that are fully transferred to the recipient.
A1: aid granted through the budget; A2: aid granted through the tax or social security system.
B1: equity participation in whatever form.
C1 and C2 cover transfers in which the aid element is the interest saved by the recipient during the period for which the capital is transfered at his disposal.
C1: soft loans; C2: tax deferral.

international networks tend to be of a public nature while those from advanced regions tend to be private firms. That is, there is unequal regional access (Boeckhout and Molle 1982) and receptivity (CADMOS 199: 65) to innovation, which works against the development prospects of LFRs.

In line with all of the above, statistical analysis also confirms that there are three broad types of regional profiles of the science and technology system in Europe. Profiles related to (1) developed economies, (2) 'dual economies' in transition, and (3) less developed economies (see Figures 1–3). Developed economy profiles are characterized by similar levels of R&TD intensity (gross expenditure in research and development as a percentage of GDP well above the EC average of 2%) and a comparable distribution of R&D expenditure among institutional actors, public and private, accompanied by similar levels of industrial productivity per capita (Figure 1).

Spain and Ireland, characterized as 'dual economies' in transition, which are in a relationship of 1 to 4 in terms of R&D expenditure per capita *vis-à-vis* the developed economies, have approached the 'developed economy' R&TD profile during the past decade quantitatively as well as qualitatively (Figure 2). Quantitatively they have experimented with an increase in gross expenditure in research and development (GERD) between 1984 and 1990 of nearly 18% for Spain and 11% for Ireland

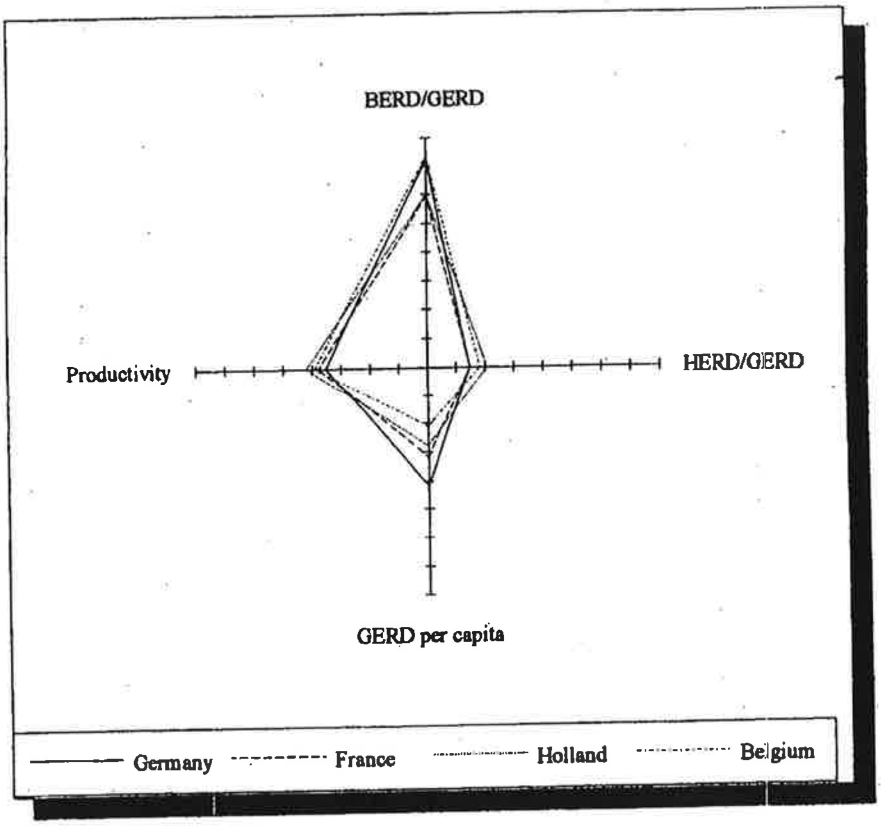

Figure 1. Developed economies.

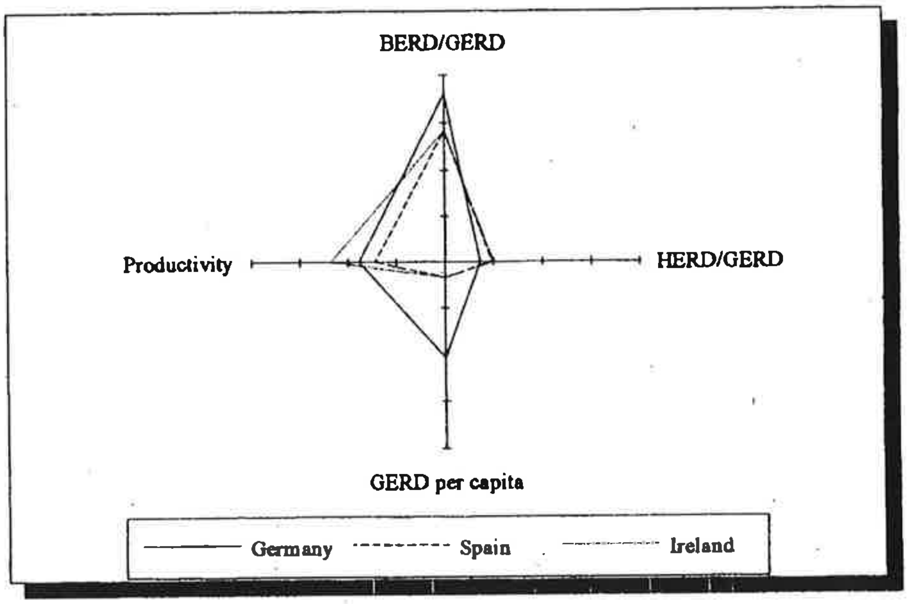

Figure 2. Dual economies in transition.

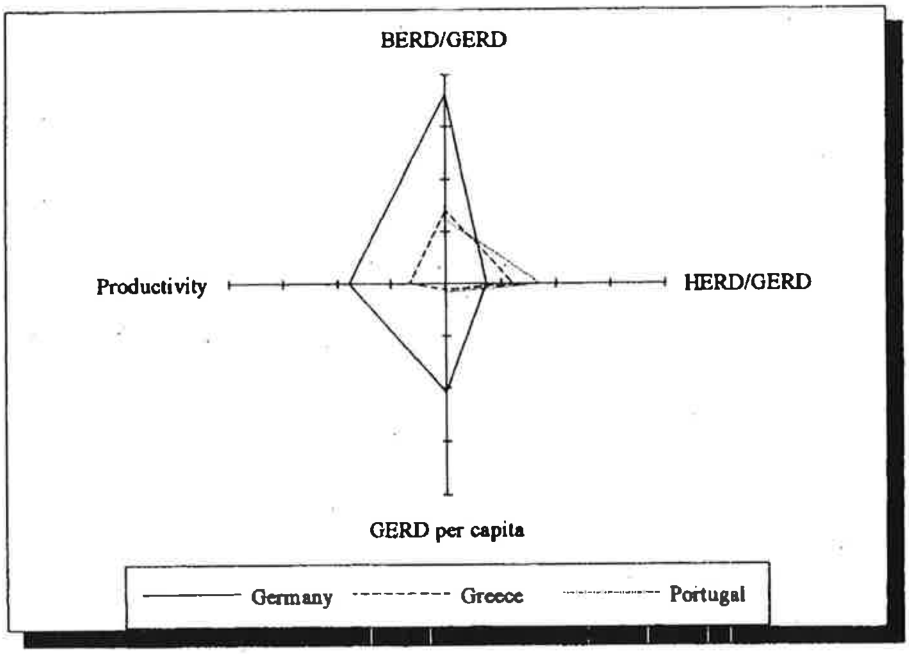

Figure 3. Less developed economies.

compared with a European average of 8% (Quintanilla 1992). Qualitatively they went through a relative reduction in higher education expenditure in research and development (HERD) and government expenditure in research and development (GOVERD) and an increase in business expenditure in research and development (BERD) (which went up 7 points to 57% between 1980 and 1990 in Spain and almost 9 points up to 60% between 1985 and 1989 in Ireland (OCDE 1992a).

Nevertheless these are national aggregate figures that conceal a dual character of their economies with markedly different regional situations, with a few 'advanced' regions rapidly catching up and approaching the 'advanced' R&TD profile while LFRs, or the 'traditional economy' (which is not easily differentiated territorially) in the case of Ireland, developed a profile that remained distorted away from that of developed economies and in some instances the technology gap increased even further. In Spain, for example, while the national total of R&D expenditure by the private sector was nearly 60% of the total in 1991, the average for LFRs was 30% (similar to the Greek rate of 28%). The same goes for R&D intensity, with a GERD per capita rate of Spanish LFRs half the national rate, a figure similar to that of the national total for Portugal. This is why one refers to these countries as 'dual' economies at two speeds, with a few advanced regions making the transition towards an 'advanced' profile in quantitative and qualitative terms and many LFRs stagnating at under-developed levels.

The 'technological profile' of the less developed regions is characterized by science and technology systems that are less developed than the Community average, where the public sector is over-represented compared with the private sector, which are primarily directed towards the 'upper layers' (precompetitive research) and which geographically are highly concentrated. These trends became more marked during the 1980s (Table 3).

During this period, in Portugal and Greece, as well as in most Spanish and Italian Objective 1 regions (and possibly the Irish 'traditional economy' including most of the native SME sector), the R&TD profile became even more 'distorted' away from the

Table 3. National R&D Profiles

	BERD/GERD (%)	*HERD/GERD (%)*	*GERD per capita (10 PPS)*	*Productivity (Ecus × 1000)*
Advanced countries				
Germany	72.40	14.60	41.70	35.40
France	59.50	14.80	31.70	37.90
Holland	60.00	20.70	28.00	42.00
Belgium	73.60	18.20	21.20	39.10
Countries with a majority of less favoured regions				
Spain	56.80	19.20	6.60	28.90
Portugal	24.60	34.00	3.20	
Ireland	56.80	19.90	6.60	47.30
Greece	28.20	24.20	2.20	13.10

Sources: Eurostat (1994) and Visa database (1994).
BERD: Business expenditure in research and development.
GERD: Gross expenditure in research and development (Business + Non-Profit + Public = Universities (HERD) + Public Laboratories).
HERD: Higher Education Expenditure in research and development.
Productivity in the industrial sector per employee per year.

advanced economy R&TD profile, with a relative increase in HERD (going from 21% in 1986 up to 35% in 1989 in Greece and from 30 to 35% during the same period in the case of Portugal) a reduction in BERD and a relative stagnation of the global intensity of the R&TD effort (Figure 3).

The qualitative differences noted in the science and technology systems in the less developed regions as compared with advanced regions suggest that the injection of public funds into research activities in such regions will produce a lower economic return than in other, more developed, regions since such resources will be absorbed by existing structures, most of which are directed towards 'pure' science at the expense of innovation.

It follows that from the regional development point of view, for these regions in particular, the scarce financial and human resources available for R&TD have to be guided and directed towards innovation efforts whose goals are more related to economic development. This may require not simply an increase in the rate of implementation of R&D expenditure in firms, which can quickly run into problems of absorption directly related to the human resources available, but also the direction of work in technology centres, university departments and public laboratories towards economic objectives more closely linked with raising the potential for innovation of the regional productive system. This does not, however, appear to have been the case in recent years in most of the LFRs. Most public policies to promote innovation (particularly those on a national scale) tend to perpetuate these structural imbalances related to a distorted 'LFR R&TD profile' rather than correcting them.

Finally, it is important to note that the 'technology gap' in the less developed regions can be seen not just in the differentials in financial and human inputs in the various regional science and technology systems but, most importantly, also in terms of their structural factors related to their productive structure, institutional framework and specific features of the regional demand for innovation. That is, in our view, the inter-regional technology gap and the innovation 'problem' in LFRs is not only a quantitative problem measured in terms of availability inputs in the system but first and foremost a qualitative problem that refers to the structural factors besetting the regional innovation systems in LFRs (some of which are pointed out in the following Table 4). It follows that a regional policy that tries to promote innovation should aim first at correcting these structural problems in each particular regional setting before trying to redress the quantitative gap by means of providing new inputs into the regional innovation system.

In the current situation the injection of public resources in LFRs will in all probability result in an injection of 'science' into the science and technology system which, in view of the excessive size and disconnected nature of the scientific sub-system with the demands/needs of the industrial tissue, will not give rise to a substantially greater regional potential for innovation that could help the economic development of such regions. The shortcomings of the science and technology system in the less developed regions mean that, paradoxically, in those places where there is the greatest need for the absorption of scarce public assistance to promote innovation, the greatest difficulties in absorbing such assistance occur. In the author's view, this shows that the effective stimulation of regional innovation in the less developed regions cannot solely rely on public assistance for financing new inputs into the R&TD system: first of all, the regional innovation system itself has to be changed in a way that will permit more assistance to be absorbed and used better.

Table 4. Some structural factors affecting the technology gap in the less favoured regions in terms of their productive structure, institutional framework and demand features for innovation.

1.	Shortcomings relating to the capacity of firms in the regions to identify their needs for innovation (and the technical knowledge required to assess them) and lack of a structured expression of the latent demand for innovation.
2.	Scarcity or lack of technological intermediaries capable of identifying and 'federating' local business demand for innovation (and R&TD) and channelling it towards regional/national/international sources of innovation (and R&TD) which may give response to these demands.
3.	Poorly developed financial systems (traditional banking practices) with few funds available for risk or seed capital (and poorly adapted to the terms and risks of the process of innovation in firms) to finance innovation, defined as 'long-term intangible industrial investments with an associated high financial risk' (Muldur 1992).
4.	Lack of a dynamic business services sector offering services to firms to promote the dissemination of technology in areas where firms have, as a rule, only weak internal resources for the independent development of technological innovation (Capellin 1989: 9).
5.	Weak co-operation links between the public and private sectors, and lack of an entrepreneurial culture prone to inter-firm co-operation (absence of economies of scale and business critical masses which may make profitable certain local innovation efforts).
6.	Sectoral specialization in traditional industries with little inclination for innovation and predominance of small family firms with weak links to the international market.
7.	Small markets with unsophisticated demand which does not encourage innovation.
8.	Little participation in international networks, scarcely developed communications and telecommunications networks, difficulties in attracting skilled labour and integrated know-how.
9.	Few large (multinational) firms undertaking R&D on the frontiers of technology with poor links with the local economy.
10.	Lower level of public assistance for innovation in aid intensity and number of schemes poorly adapted to local SMEs innovation needs.
11.	Lower quality and quantity of scientific infrastructure and science-technology systems less well integrated into the needs and capacities of the regional productive system.

This paper argues that balanced growth in the science and technology system in the less developed regions which can make a significant contribution to the innovative potential of those regions and hence to their economic development depends on the prior establishment of a strategy to link that system to the interests and needs of the region's productive system. This implies substantial structural changes as well as a new set of relationships between the key regional players (the science and technology community, the regional and national public sector and the private sector in particular) so that the science and technology system can be given a fresh orientation.

3. Some policy lessons from regional Community policy in addressing the inter-regional technology gap: STRIDE (Science and Technology for Regional Development in Europe) in Objective 1 regions (LFRs)

STRIDE is a Community initiative for the promotion of innovation and R&TD efforts in the less favoured regions of the European Union. It had a budget of 400 million Ecus (grant aid up to three-quarters of eligible costs in Objective 1 regions) and it ran for 4 years starting in 1990 (Table 5).

Table 5. The STRIDE programme in the Objective 1 regions.

	ECU million	*% of total*
A – Strengthening innovation infrastructure in Objective 1 regions		
Aa – Assessment of R&D potential and its contribution to regional development	4	0.6
Ab – Equipment, including intangible, and R&D infrastructure not included in the CSFs	363	58.6
Ac – Additional current expenditure for specific R&D projects	2	0.3
Total for type A measures		**59.5**
B – Promotion of participation in national and international R&D programmes		
Ba – Dissemination of information on community R&D programmes	11	1.8
Bb – Preparatory work on research cooperation projects	3	0.5
Bc – Demonstration and pilot projects to apply the results of Community R&D	0†	0
Bd – Co-operation agreements between R&D centres in Objective 1 regions and those elsewhere	1	0.2
Total for type B measures		**2.5**
C - Co-operation between industry and R&D centres		
Ca – Consortia to promote co-operation between universities, R&D centres and firms	14	2.2
Cb – Joint research projects involving at least one firm	30	4.8
Cc – Transfer of technology and innovative services in partnership with firms	175	28.2
Cd – Inter-regional technological co-operation networks	0	0
Ce – Vocational training programmes requested by the productive sector	14	2.2
Cf – Training for researchers from Objective 1 regions	0	0
Total for type C measures		**37.4**
Other:		
Technical assistance, assessment and monitoring, etc.	3	0.5
Total	**620**	**100**

†The figures quoted in this table are estimates made by the author, not official figures.

An analysis of the structure of expenditure under the STRIDE regional operational programmes and of the structural details and technological profile of the less developed regions gives rise to the question of why it is that some regions have:

1 an imbalance in the science and technology system in favour of the public sector, and the academic part in particular (concentration on the higher levels of the Science-Market circuit and over-representation of the science sub-system in terms of the 'innovative environment') with very low levels of innovation in the private sector;
2 low levels of technology transfer between public R&D centres, universities and the private sector (little co-operation and lack of 'intermediaries') and among those firms themselves (lack of coherence and integration of the scientific sub-system into the productive context, mismatch of the regional supply of innovation with demand, and lack of links between the various stages of the process of innovation in the region); and

3 weak or non-existent links between firms and regional Innovation centres and international networks offering access to the new sources and technological partners required to provide the fresh contacts and knowledge that will facilitate incorporation of technologies into the productive structure of the region.

The authorities responsible for regional economic development in these regions have the opportunity to invest in the promotion of Innovation by means of grants in order to increase the competitiveness of the regional economic structure with considerable scope for manoeuvre. They may select measures from:

1 strengthening innovation basic infrastructure in the Objective 1 regions;
2 encouraging participation in national and international R&D programmes; and
3 co-operation between industry and the R&D centres.

They generally tend to draw up operational programmes whose implicit strategy (which in most cases is not set out within the programmes) does not closely reflect the needs of their structural characteristics and technological profile and which are based on the following.

1 low participation by the private sector and little attention to technology transfer projects;
2 infrastructure measures designed to boost public centres, usually academic ones, not closely involved with the structure of production in the region;
3 little participation in measures intended to foster links between innovation centres and firms with international programmes and co-operation networks; and
4 little attention to training of the work force and retraining for human resources (which constitute a strategic resource and one of the main bottlenecks to permanent adjustment of the regional economic structure to technological change).

In the author's view, the basic reasons for this apparent contradiction are two-fold. First, in the absence of an analysis of the specific features of supply of, and demand for, Innovation in the region (including any areas of complementarity and shortcomings), some of those responsible for regional planning use as a point of reference for preparation of the STRIDE operational programmes a 'linear' model of the process of regional innovation (often implicit in nature). That is, they assume that investment in the 'upper layers' (or the injection of science into the system) will automatically mean that the new R&D effort will have an economic effect on the market.

They therefore ignore the limitations of this model (for example, as far as the interrelation between stages and their retroactive nature (Soete and Arundel 1993), the importance of the identification and structured expression of demand by small firms, the existence of bottlenecks and the need for interfaces between the scientific subsystem and the productive context are concerned) and its shortcomings as a model to explain the 'economic' nature of the process of innovation. To sum up, they employ a reference model whose powers of illustration are inadequate for it to be used as a tool for planning a programme to support innovation, whose final aim, let us not forget, is regional development.

Second, some regional planning administrations have little experience of the key strategic approaches in this field (which inevitably require a multidisciplinary approach with links to both the innovation community and the private sector). In general, these administrations tend to favour (for reasons of efficiency, term and available resources) large (infrastructure) projects that are easier to manage than a large number of smaller projects, normally less easy to pin down and more indirect in nature (preparation of appropriate environments, provision of services and external economies, etc.), which must be adapted to differing socio-economic situations and count on a large number of those involved in the economy.

That is to say, these are projects that require among other things a high degree of decentralization in their design, management, implementation and monitoring as well as a certain degree of consensus and co-operation with key regional players. This suggests that an increase in the innovative capacity of the regional structure inevitably requires new forms of organization and institutional co-operation to help to improve the 'structural competitiveness' of firms in the less favoured regions (Landabaso 1992: 120).

The problem of absorption of funds and the guidelines followed in planning STRIDE expenditure to support innovation in the Objective 1 regions bring to the fore a number of structural problems and institutional deficiencies in the context of the less developed regions: in the absence of a regional strategy to promote innovation that can help to create an 'innovative environment' through more and better co-operative links between those working in innovation in the region, an injection of public funding into the system will not result in a substantial increase in the contribution made by that funding to regional economic development.

The 'economic' return (in regional development terms) of the injection of a given quantity of public funding into the regional innovation system will be much greater in advanced regions. This is primarily the result of the structural characteristics and institutional effectiveness of their innovation systems, including improved integration of the scientific sub-system into a productive context more propitious for innovation. It also results from a higher level of co-operation between firms and between the public and private sectors and greater institutional efficiency (Piore and Sabel 1984: 17), which includes the public sector's planning capacity and the existence of intermediaries between those active in the local economy and technology (Cooke and Morgan 1992: 114).

4. The Science-Market circuit: a tentative regional model of the innovation process

Regional economic analysis can bring new ideas and perspectives to explain the differences between regions in their innovative capacity. It can help to clarify the economic mechanisms that link the innovation effort to the competitiveness of the regional productive structure. It can also help to identify the policies to promote innovation that are most appropriate in the regional context. The author believes that the main aim of regional economic analysis' should be to identify and explain how the Innovation effort may best be converted into regional competitive advantage. In order to meet the theoretical challenge mentioned in the introduction it is first necessary to define the innovation process at regional level and then to try to identify a model through which this process can be analysed. The definition of the process of innovation as a systemic (Soete and Arundel 1993: 29) phenomenon based on the accumulation of learning processes through networks of co-operation (mainly public/ private and between firms) which encourage interaction between those engaged locally in the economic and technological life of the region is used here.

A model, by definition, has to be simple and descriptive of the basic nature of the process that it tries to analyse. The Science-Market circuit model proposed (Figure 4), seeks precisely to resolve some of the methodological problems encountered in integrating the process of innovation into the regional analysis through a theoretical model that can identify and relate the various stages and functions of the process and stress both its economic significance and its interrelationships with the various regional actors, the institutional framework and economic policies within a regional context. In short, the model seeks to describe the process of innovation, understood as the process of continuous adaptation to technical change within a particular regional economy from the standpoint of development economics. Moreover, the model seeks to identify the mechanisms of the innovation process through inter-related functions and stages of the technico-economic process by means of which the innovation effort yields concrete results in the market-place (competitive advantages) within a specific socio-economic and institutional context at regional level.

Several assumptions are built into this model.

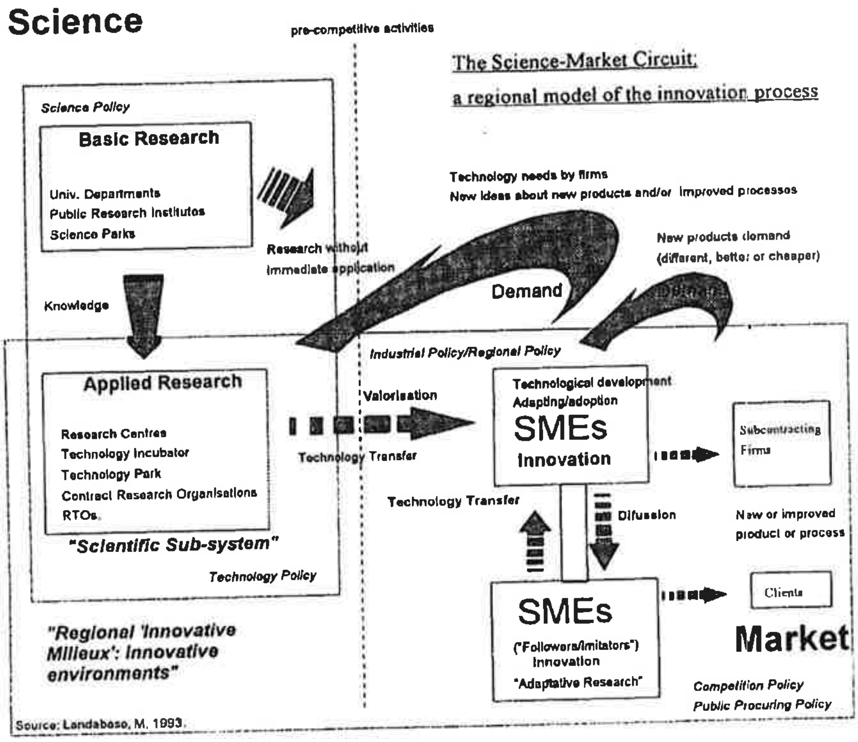

Figure 4. The Science-Market circuit: a regional model of the innovation process.

1 R&D work does not necessarily generate technological innovation, nor is it the only precursor of such innovation (Rosenberg 1981: 147, Solé Parellada and Barceló 1988: 27) in particular when referring to a regional productive tissue in a LFR. The latter is normally based on small and medium enterprises that are essentially 'technology-followers' for which innovation is often derived from the process of adaptation/adoption of technologies that are well established in international markets. That is small firms in these regions are not only badly equipped to develop substantial R&TD efforts by themselves but also find it difficult to adequately 'search' and 'assess' those existing technologies elsewhere that best fit their productive activities.
2 It is defined as a circuit precisely because it generates inter-relationships (normally of a circular nature) among the various activities (*in which demand flows play the key role*) – a process of innovation may begin with any one of them.
3 No 'natural' linear flow is assumed between the various stages.
4 The process of innovation does not follow the principles of chemistry: in each region the mixture required to produce a 'reaction' (i.e. to maximize the developmental impact of innovation) is different.
5 This model is specific for each particular region since the innovation process in the regions, LFRs in particular, is fundamentally an indigenous process and its characteristics vary most particularly in relation to the region's general level of economic development.
6 The model contains an artificial segmentation by stages and functions so that different activities can be 'territorialized' and so that the process of innovation may be placed within the context of regional economic development. In this sense, it enables one to associate separate activities with different policies, institutional actors or even territorial areas and so facilitates quantification using statistical indicators (such as in Table 1). This also enables one to associate the process of innovation with a variety of regional profiles (Table 3 and Figures 1–3).

However, there are several important limitations to the model. First, it seeks to be solely a descriptive model of the regional aspects of the economy of Innovation. Second, it is used to illustrate a debate on options and regional development. Finally, it does not cover all relevant aspects of the innovation process, nor does it seek to provide a universal explanation of that process. Nevertheless, this model may allow one to identify and start investigating two key components of the process, the scientific sub-system and what it is called the innovative regional environment, and their inter-relations.

4.1 The scientific sub-system

The Science-Market model enables one to reflect on the level of integration of the scientific sub-system into the process of innovation in a particular region. It may tell us, for example, that in the less developed regions, the basic R&D effort (the upper layers of the Science-Market model) is less relevant as a source of innovation than in other types of regions because of the specific features of the productive structure in these regions and, in particular, their weaker links between the various layers

(Cappellin 1992: 16) and the lack of complementarity and coherence amongst the different stages and activities within the circuit. This results in the guidelines and priorities of the scientific sub-system being less relevant to the needs and demands of the structure of production in the less favoured regional context due to the following factors, among others.

1 Sectoral specialization in traditional sectors: firms with a weak scientific base.
2 Size of firms: lack of availability of financial and human resources and of knowledge for concentration on pre-competitive research (long-term economic results).
3 Distancing of the academic system from the productive context: a large amount of the R&D effort turns into outputs that are residual to the system from the point of view of regional development.

Finally, understanding the actual sources of innovation for small firms, which vertebrate most of the industrial structures in LFRs, are critical in this respect. There is now some empirical evidence (Dankbaar *et al.* 1994) that demonstrates that the main sources of ideas for innovation in small firms are primarily (i) customers, (ii) competing small firms, (iii) suppliers, and only afterwards (iv) universities and public research laboratories. Moreover, sources of technology depend critically on (a) access to qualified staff and training, and (b) co-operative research by firms.

In view of all of the above, it can be assumed that in this regional context demand flows and the quality of the so-called 'innovative environment' play a critical role in facilitating the innovation process at regional level (Aydalot 1986, Camagni *et al.* 1992: 34, Maillat and Lecoq 1993: 359). This is why one concludes that the aspects related to demand and absorption capacity (management, entrepreneurial culture) in firms are more important than those relating to the supply of R&D and scientific infrastructure in the less developed regions. Nevertheless, this does not mean that one should underestimate the so-called scientific sub-system and it should not be forgotten that:

1 the importance of the scientific sub-system as an enabling factor that permits the search for, identification, adaptation and adoption of technology and new technological knowledge (Malecki 1991: 158) from external sources for local firms in the less developed regions;
2 it is a regional source of research and knowledge, scarce human resources (Coombs and Fontes 1993: 42), information, contacts with other countries and access to multinational co-operative research programmes; and
3 the regional scientific sub-system is not important in itself as a source of research results but rather through the training of highly qualified research staff acquainted with techniques (and with networks of professional contacts) who can help to solve specific industrial problems (Pavitt 1994: 29).

If the scientific sub-system is not integrated into the overall process of innovation, it will be hard for small firms in the less developed regions to be able to bear the costs and difficulties associated with the effort of innovation required to maintain or increase their competitiveness in an increasingly internationalized market.

4.2 The innovative environment: definition and characteristics

The innovative environment refers to the set of relationships, normally interactive ones – networks (competition and co-operation between firms, transfer of technology, co-operation on R&D, production and sales, information, informal relations, etc.) which exist between the main economic and technological actors in a region (subcontracting firms, clients, competitors, business services, technology transfer centres, public laboratories, University R&D departments, regional development agencies, etc.) and which provide the organizational basis for the local productive system. These relationships, associated with the lower stages of the Science-Market circuit, take place in a particular local economic context (with a particular entrepreneurial culture, level of training of the work force, sectoral specialization, etc.) and institutional setting. They have an interactive nature and they may be 'formalized' through commercial flows, technology transfer or technical assistance, for example, or they might just be based on human contact and informal channels of information and tacit knowledge.

One illustrative and paradigmatic example is provided by technology parks (TPs) in the less developed regions. In the less developed regions, unlike those that are more developed, the failure of rich innovative contexts to appear spontaneously, or the difficulties which that process has encountered, has resulted in an option for the artificial creation of such contexts through TPs. TPs in these regions are normally instruments to promote regional innovation based on the development of synergies derived from co-operation between R&D centres, laboratories and firms based on geographical proximity. TPs typical objectives in LFRs are (Segal and Quince 1992) (1) promotion of new technology based firms (diversification) (2) attraction of foreign capital with a high innovation content (internationalization), and (3) promotion of the dissemination of technological development (modernization). In this sense TPs act as a filter selecting those firms most inclined to innovate and concentrating them in an area where synergies and the scope for co-operation between firms and between the public and private sectors (which is essential to encourage innovation) are more likely to grow. TPs in LFRs can also act as interfaces between the demand for technology in a region (demand pull) and its supply (regional, national or international) by making them more complementary and so rendering the process of innovation more coherent and integrated. That is, in the Science-Market model they would have a key interface role in particular between the scientific sub-system and the productive context.

In the less developed regions, the innovative environment or 'regional productive context' and relationships between firms, flows of technology and the institutional support associated with them has greater importance than elsewhere as a means of access to the sources and media required to promote innovation. This environment is fundamental since, in less developed regions, firms are consumers of technology. For certain regional economists (Aydalot 1986, Camagni *et al.* 1992, Maillat and Perrin 1992) it is precisely the 'innovative milieu (environment)' and not necessarily each individual firm that is responsible for the process of innovation in a particular region. The innovativeness of the firm is determined by the 'milieu', which represents for them the main source of innovation in a region and therefore the main area to concentrate policy efforts.

In the author's view, the less developed regions should ensure that the process of innovation, understood as a complex, interactive and continuous process, is adequately supported in all its dimensions (social, organizational, economic and technological) through policies of public support to avoid its being interrupted, with the attendant risk of economic decline and marginalization on the international market.

5. Towards a new regional policy to promote innovation: regional strategies for innovation

The author has sought to establish the following points throughout this paper:

1 regional disparities are primarily due to differences in the productivity and competitiveness of the various regional structures of production in which innovation and innovation effort, although not the only factors, are of fundamental importance;

2 the factors that stimulate technological development and regional innovation are more prevalent in the central regions of the European Union (Hingel 1992: 12);

3 there is a tendency for these factors to be mutually reinforcing, which, in turn, creates certain economies of scale and facilitates the successful exploitation of external economies that may generate the critical masses and synergies required to encourage innovation in the more advanced regions in particular. A 'Myrdalian causation' effect (Myrdal 1957) may be present through which there is a process of regional concentration of innovation resources in advanced regions which starts up a 'virtuous circle'. That is a self-sustaining process of increased technological demand followed by the development and upgrading of regional innovation capacities which drives on economic development, and so on. This process would be fed by the regional concentration of (i) economies of scale (i.e. R&D centres that serve a number of firms and permit a concentration of top class researchers) (ii) externalities (i.e. creation of a scientific community and technical culture between heads of firms, new relations between and with the R&D community), and (iii) economies of agglomeration (i.e. concentration of technological resources to act as centres of attraction for the location of intensive investment in certain types of technologies).

It may be concluded that the design and implementation of appropriate measures and programmes, to promote innovation within the Community's regional policy, and able to offset the disadvantages described above, are of vital importance if the European Union is to implement effectively the principle of economic and social cohesion through the sustained economic development of the less developed regions. If these measures and programmes are not forthcoming, the gap in cohesion, driven by increasing regional disparities in innovation, can be expected to increase, which will have an undoubted impact on the distribution of economic activities in the territory of the Union.

In the author's view, the results of the analysis of the level and type of measures for the promotion of innovation supported by the Structural Funds in the less developed regions between 1989 and 1993 demonstrate (Circa Group Europe 1993) the need not only for a substantial increase in the amount of budgetary funding allocated to innovation in the next generation of Community support frameworks but also, and still more important, for the reorientation of those means of promotion. That is, moving from concern for supply of innovation to demand means moving from an assistance model targeting the so-called upper layers of our Science-Market circuit (in which assistance to basic research in university or public bodies and finance for infrastructure dominate although at substantially different levels) to a different model better adapted to the needs and capacities of the productive system of each particular region.

The author believes that this rebalancing should be based on prior support from regional policy for the creation of intermediate structures that encourage co-operation between the public and private sectors and links between supply (international or regional, through its improvement and extension) and regional demand, once this has been properly identified and expressed in a structured form. All this would be accompanied by public support to offset the shortcomings of the institutional, social and economic organizational framework into which the scientific and technological factors have to be integrated. It is considered that, for the Structural Funds to be effective under these new guidelines for Community regional policy, they should support the development of regional strategies on innovation that would enable the design, implementation and assessment of innovation infrastructures and programmes in the less developed regions to be considerably improved. This policy should seek both to increase innovation effort in the less developed regions and adapt it to the specific features of each particular regional structure of production.

Where there is no strategic planning able effectively to establish a consensus on objectives and networks of co-operation between those concerned with the economy of the region, the effectiveness of this type of regional policy will be devalued. The aim in fact is to identify the points of intersection of the various stages of our Science-Market circuit so that all involved in the region can be integrated into stable networks of co-operation that facilitate the creation of an environment more propitious to Innovation.

The process of preparing a regional strategy for innovation means that co-operation can be integrated into a stable institutional framework that encourages contacts and the search for partners, clarifies the objectives of public policy in this field and, perhaps, makes available to firms public resources to encourage their participation in joint projects. In short, the process of preparing a regional strategy for innovation should concentrate on:

1 giving priority to identifying and expressing latent R&TD demand in regional firms;
2 seeking to 'marry' latent demand for innovation and technological development in the productive structure of a less developed region, and in particular of SMEs, with supply within the region (endogenous) and at national and international level (exogenous);
3 identifying realistic objectives that bring together and concentrate scarce regional resources for TIR&D and innovation, and providing a framework for optimizing policy decisions regarding future investments in R&TD initiatives at the regional level;
4 responding to the question of how to promote co-operation between SMEs, the research community and public administration; and
5 building consensus and co-operation at regional level on priorities for action between the principal actors involved, which can be integrated into a stable institutional framework that encourages contacts and the search for partners.

The author therefore regards as essential an approach that is:

1 regional, that is, it must relate to a specific geographical area but take full account in its definition of the national and international context in which it is operating;
2 'bottom up', in which both the private sector and representatives of the regional and national scientific and technological community take an active role. The idea is to provide for a stronger regional partnership through this approach. It is the regional actors that have to establish what they want and how to achieve it. It is therefore necessary to ensure that there is a strong demand driven approach built in this exercise, with an emphasis on SMEs;
3 strategic and co-ordinated, based on environment and long term criteria and placing its policy of promoting TIR&D within the context of industrial and regional policy;
4 an integrated approach: it should try to link efforts from the public sector (local, regional, national and European) and the private sector towards the common goal of increasing regional productivity and competitiveness;
5 multidisciplinary, taking technological, economic and institutional criteria fully into account; and
6 international and co-operative, with the international market as a compulsory reference point and with external sources and technological partners investigated. That is it should keep an international perspective in terms of the analysis of global economic trends as well as on the need to co-operate nationally and internationally to be more effective in the field of R&TD and innovation.

The final objectives of this strategy are:

1 Institutionalization of an on-going and structured review by all those concerned in the economy of the region of the opportunities and consequences that stem from the process of adjusting the economy of the region to technical change (Petrella 1987: 5) (create a clear strategic framework for innovation in the productive structure of the region).
2. Help to improve the dynamic effectiveness with which firms and institutions can disseminate, adapt and adopt innovation on the basis of information and knowledge (establish networks of co-operation within and between firms and identify and prepare projects for technological innovation in firms).
3. Help the regional economy to secure competitive advantages through ongoing adjustment to technical change (strengthen R&TD supply in the region (avoiding duplications and filling gaps) and help in the design of new public and private programmes to promote innovation).

In conclusion, a regional technology strategy should be designed to respond to the question of how to promote co-operation between SMEs, the research community and Public Administration to assess technology requirements and to audit local needs, capabilities and potential with a view to improve the innovative capacity of a region and its international competitiveness.

A programme with these features, which gives priority to questions of demand and identifies certain realistic objectives which bring together and concentrate scarce regional resources for TIR&D and innovation, would stimulate the innovative environment in the less developed regions by improving co-operation between firms and facilitating the integration and coherence of the scientific sub-system (at regional/ national or at Community level) into the overall process of regional innovation.

6. General conclusions: co-operate locally to be able to innovate in order to compete globally

Given the correlation of innovation and R&TD efforts with regional economic development, closing the inter-regional 'technology gap' in the European Union, which risks further widening, becomes a pre-condition for reducing the 'cohesion gap', which is the primary objective of regional policy (at international as well as at national level). It follows that regional policy should increasingly concentrate its efforts in the promotion of innovation if it is to be successful in creating the conditions for a sustained (and sustainable) economic development process in less favoured regions. Hitherto, support for the promotion of innovation in the less developed regions has been generally inadequate in quantity and quality to meet their economic development needs and it has not been adapted to the specific characteristics of the process of innovation in different regional contexts, LFRs in particular.

The inadequate intensity of the innovation effort by the public sector and particularly by the private sector, and its poor adaptation to the specific needs and conditions in the less developed regions (due to a lack of understanding of the innovation process at the regional level) helps to increase the 'technology gap' between regions and tends to perpetuate or even increase the 'cohesion gap'.

The greater effectiveness of regional policy as an instrument of economic development in the less developed regions entails the definition of regional policy to promote innovation that:

1 is adapted to the particular features of the innovation process in the less developed regions and concentrates in the creation of the appropriate conditions (in particular those of an institutional and organizational character within each regional innovation system), which enables these regions to develop more efficient policies for the promotion of innovation;
2 is able to link up with and integrate into the other industrial, technological and regional measures and policies within a medium- to long-term planning horizon; and
3 can contribute to a successful response to the main challenges facing firms in the less developed regions in the medium term (i.e. a faster economic integration process and greater competitive pressures from the newly industrializing countries).

The main aim is to raise competitiveness through the modernization and diversification of the productive structure of the region by making permanent adjustments to technical change using the international market as the constant point of reference.

One practical way to approach this problem may be to encourage regions to develop regional innovation strategies. These strategies should aim at promoting public/private and inter-firm co-operation and creating the institutional conditions (consensus among the key regional players) for a more efficient use of scarce public and private resources for the promotion of innovation (bigger and better spending in this field through regional policy). That is, to design new ways of introducing technological innovation in the regional economic development agenda of the less favoured regions.

Notes

1. A version of this paper was presented at the International Workshop on Regional Science and Technology Policy Research in Himeji, RESTPOR '95, 13–16 February 1995 organized by Japan's National Institute of Science and Technology Policy (NISTEP).
2. The opinions expressed in this article are those of the author alone and not necessarily those of the European Commission.