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Abstract

To date, EU policy has been in favour of balanced regional growth. Since the 1980s, the EU has adopted a policy which aims to strengthen the science and technology bases of the member states, which is necessary to increase their competitiveness. This EU RTD policy also contributes to other Community policies such as economic cohesion. Competitiveness and cohesion are two basic elements which are necessary for balanced economic growth. Despite these objectives, many economic and technological differences still exist between European regions. To show these differences, we present in this paper a new typology of regions which are categorised on the basis of their current state of economic and technological development, their short term evolution in technological development and their short term economic growth. Further, we analyse whether these different types of regions tend to converge or diverge, both economically and technologically. Because technological development is the foremost factor used to explain economic growth we further analyse the role of EU RTD policy to diffuse technology from the economically more advanced to the less advanced regions. To explore this question, we use a unique set of regional data relating to participation and collaboration in the EU Framework Programmes. Regional participation data is used to measure the direct impact of EU RTD policy on technology development, while the collaboration data is analysed by means of social network techniques as an indicator of technology diffusion. It is shown that the current RTD policy enforces the technological strength of the best performing regions, but plays a clear role in technology diffusion towards a limited group of catching up regions.

Keywords: regions, technology, growth, policy, cohesion

1. Introduction

It is remarkable that during the last two decades, regions have become increasingly pro-active in defining their economic and technology policies. The reason for this can be found in the basic elements of the knowledge based economy, which promotes continuous interaction and learning between the different actors (Florida, 1996). Hence, local clusters emerge with their own specific needs (OECD, 1996). National governments have increasingly recognised the need to adapt their policies to these local needs and therefore have increased regional autonomy. The European Union has encouraged this trend with the launch of such projects as Regional Innovation Infrastructures and Technology Transfer Strategies (RITTS) and Regional Technology Plans (RTP).

Parallel to these policy developments, the regional dimension started to receive broader attention in the academic community of economists. Previously, regions had largely been the playground of regional economists and economic geographers, who focused mainly on the spatial clustering of regions (Malecki, 1991) or provided descriptive analyses of regional clusters such as the high-tech phenomenon of Silicon Valley and Route 128 in the States (Saxenian, 1994). A major shortcoming of this literature is that it does not give an insight in the importance of the regional dimension for general economic questions such as growth, nor of its relevance for economic or technology policy.

Recently, scholars of the convergence literature such as Sala-i-Martin (1993), Fagerberg and Verspagen (1996) and Neven and Gouyette (1995) showed that regions are a useful unit of analysis to study the economy-wide question of cohesion. Convergence economists study the key question whether poor countries (or regions) tend to grow faster than rich ones. In other words: are there automatic forces that lead to convergence over time? Recently, Quah (1997) argued that much of the economic disparity between member states of the European Union is hidden by the intra-country differences between regions. The interesting contribution of the convergence economists is that they have (empirically) shown the importance of the regions for analysing dynamics at the level of the whole economy. However, their results remain very much rooted in the neo-classic growth models, which assume a causal relation between technology and growth.

In this paper, we combine the qualitative, descriptive approach of the regional economists (Malecki, 1983; Harvie, 1994) with the quantitative, aggregate analysis of the convergence economists (Barro and Sala-i-Martin, 1992; Bernard and Jones, 1996). Leaving the growth models for what they are, we are able to incorporate a systemic dimension in our analysis of technological development and economic growth. In the first part of the paper, we use the technique of cluster analysis to categorise the regions into different ‘groups’ based on their technological and economic performance. Specific attention is paid to how these clusters will evolve in the future. Will they all converge towards one club of regions of similar economic state as suggested by the neo-classic economists? Or, can we expect a different number of such convergence clubs?

Notwithstanding major differences between the regional economists and convergence economists, both agree on the idea that technology plays a major role in the process of economic growth. Therefore, we focus in the second part of this paper specifically on the role which the EU technology policy plays in shaping the regional landscape. Technology policy includes both the stimulation of technology developments (R&D activities) and the diffusion of technology throughout Europe. To explore these questions in further detail, we analyse a unique database of RTD participation and collaborations derived from the EU's main technology policy vehicle, namely the Framework Programme.

2. From the convergence debate towards an empirical analysis of the systemic view on technological development: a short overview.

Having its roots in neo-classic economic growth theory, the convergence literature offers an appealing point of departure to study the differences in economic growth caused by the technological potential of particular regions or countries. The neo-classic model, elaborated by Solow (1956), suggests that under the assumption of full labour mobility and under the condition that technology is a public good which diffuses immediately, each country's or region's growth path will evolve to a similar steady state (absolute β-convergence). Applying this neo-classic growth model[1], Fagerberg and Verspagen (1996:436) have calculated the convergence rate among 71 regions for the period 1950-1990. According to their model, the poorest region grew 4.3% faster than the richest one in Europe during the first half of this 40-year period (1950-1970). In the next 10 years however (1970-1980), this natural catch-up effect fell back to 2.4%. Moreover, in the period 1980-1990, the catch-up rate dropped to a mere 0.8%, which means that despite the EU efforts, the regional differences in GDP per capita remain essentially unchanged (see table 1).

Table 1: Testing the convergence hypothesis

	Constant	***LOG***$_{\textit{start year}}$	***R***^{2}	***n***
Fagerberg & Verspagen				
period 1980-1990	0.028 (4.12)	-0.006 (1.15)	0.02	67
Our study				
period 1980-1989	0.036 (0.01)	-0.0067 (0.004)	0.024	112
period 1989-1994	0.004 (0.003)	-0.0005 (0.00)	0.0004	129

Standard errors of the coefficients are between parentheses; *n* equals the number of regions included

Because Fagerberg and Verspagen only covered a limited set of regions, excluding the politically important Greek and Portuguese ones (which are all objective 1[2]), we investigated the external validity of this absence of catch-up in a much broader set of regions including many of the South European ones (see chapter 7, European Report on S&T indicators, 1997 for full description of the list of regions). The level of catch-up was investigated both in the period 1980-1989 and, more recently, during the period 1989-1994. Over the period 1980-1990, we found that the catch-up term was even less than the 0.8% reported by Fagerberg and Verspagen. This is mainly due to

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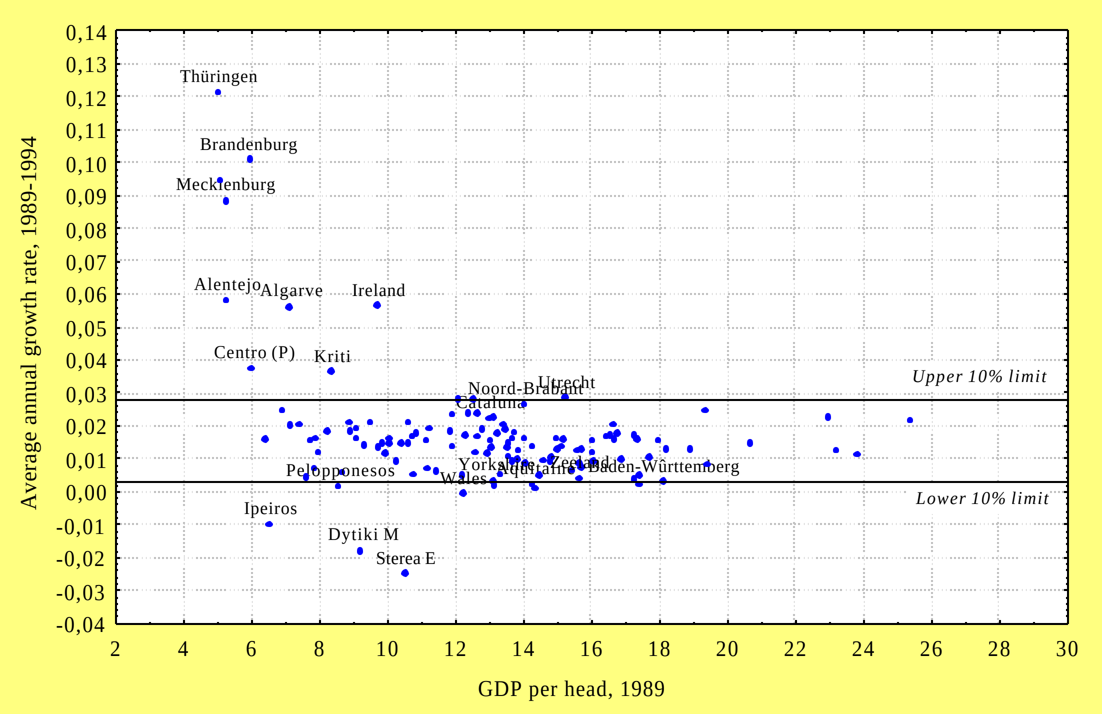
[1] In line with the suggestions by Barro and Sala-i-Martin (1992), Fagerberg and Verspagen (1996) used the following equation to measure the growth model: $\hat{Y} = a - \frac{1 - e^{bT}}{T} \log(y_0)$

[2] I.e. their GDP per capita was in the eighties 25% below the EU average.

the inclusion of the least developed (Greek) regions. For the most recent period, no catch-up at all was found, although, admittedly, this is a very short period. Given the fact that in 1989, the ratio of GDP per capita between the richest and the poorest region was more than 4:1, we can conclude that the Solow model does not easily explain this. Consistent with Fagerberg and Verspagen we could conclude that the Solow model does not pass the test of reality anymore.

The results for this most recent period are graphically shown in more detail in figure 1. Here, one can see which regions catch-up and which do not. The regions located on top of the upper line in the figure belong to the 10% fastest growing regions in Europe. Those which are below the lower line belong to the 10% least growing regions.

Figure 1: Economic catch-up in regional Europe, 1989-1994



Data: DG XII-AS/4, Eurostat

We find most variation in the lower tail of the GDP per capita. Unfortunately, this mobility is not always in the expected, i.e. upward, direction. On the contrary, the poorest Greek regions in 1989 have become even poorer in 1994. Ipeiros, Dytiki Makedonia, Sterea Ellada and Pelopponesos are those which seem to be worst off. Only a very small number of relatively poor regions such as Alentejo, Algarve, Ireland, Centro (P) and Kriti seem to catch up as predicted by the Solow growth model. The figure also shows the exceptional situation of the former East-German regions, which are catching up very fast as a result of the Western German efforts but which, economically, should be considered outliers.

As aforementioned, the absolute convergence studies depart from the assumption that catch-up will happen automatically. Apparently, this is not the case anymore. An alternative to the neo-classical model is the technology gap approach (Fagerberg, 1988; Abramovitz, 1986) which suggests that differences in technological development and social capability (the educational system, the elaboration of the financial market, etc.) condition these economic convergence rates between regions. Hence, economic convergence between regions with a very different state of technological development is not straightforward. Instead, the level of technological development (and social capability) determines the potential of economically lagging regions to catch-up with the industrial leaders. This convergence within the borders of technological distance is called conditional β-convergence. Controlling for the technological differences, Fagerberg and Verspagen found increased support for the catch-up hypothesis in their study of 71 regions. In a re-estimation of their conditional convergence model however, we did in our larger population of regions not find increased catch-up over the period 1989-1994.

Building on the ideas of conditional β-convergence, a growing number of scholars has suggested that the relation between technology and growth might be different for different clusters of countries or regions, labelled convergence clubs (Baumol, 1985; Quah, 1996 and 1997; Verspagen, 1997; Neven and Gouyette, 1995). Convergence clubs are groups of countries or regions which evolve to a similar state of economic development, given similar initial conditions such as their state of technological advancement or their social capacity (Galor, 1996). Scholars in this view are most interested to analyse how regions cluster together along their income distribution and how they change from one cluster to another over time (Quah, 1997). They use the income variable as a single variable to base their initial grouping on and consider technological development as an exogenous factor to explain inter-cluster mobility (Quah, 1996 and 1997; Fagerberg and Verspagen, 1996).

It is exactly this exogenous linear causality between technological progress and economic benefits that has been vigorously questioned in other academic circles (Lundvall, 1992; Soete and Arundel, 1993; Edquist, 1996). Influenced by interactive learning theories (Nonaka, 1991; Florida, 1995), a more systemic view on the (short and medium term) role of technology in the economy was introduced. In this view, technology and economic progress are highly interrelated with each other. Pushing just one button (e.g. the technology policy button) without making a link to the industrial structure creates anomalies, resulting in an under-achievement of the desired objectives. The systemic idea has not only found support in the academic world but has, thanks to the influence of the OECD, been widely accepted in policy making circles. In a very recent paper, Verspagen (1997) included, in line with this systemic thinking, both technology and economic variables as a basis for his clustering of 120 countries in the world economy.

In this paper, we build on the rigorous approach of the convergence club idea, but go one step further, both theoretically and empirically. First, we leave the pre-assumption that GDP per capita is the only economic conditioning variable. Instead, we incorporate a variety of economic and technology variables which allow us to build the regional landscape. Using this landscape as an initial condition, we look how these groups of regions move towards each other, both economically and technologically. Second, we add an explicit technology policy dimension to the debate through the analysis of the Framework Programme data.

3. Regional economic and technological systems in the EU: a new typology presented.

3.1 Data collection, Methodology and Regional Classification

The systems approach suggests that economic and technological development co-evolve. In line with this argument one could expect that regions can be grouped into clubs with similar technology and economic indicators. As aforementioned, we want here also to analyse the economic and technological dynamics of each region, especially at the short term. Therefore, the regional indicators are collected over a period of six years, namely from 1989 to 1994.

The regional definition used here is adapted from the Nomenclature of Territorial Units for Statistics (NUTS). Defining regions according to this classification has certain disadvantages. Caniëls (1996:18) summarised them as follows: the classification reflects administrative units which differ in size, although the NUTS system tries to reduce these size disparities (Molle, 1980). Second, the administrative regions do not map exactly on the economic ones (Richardson, 1978). Third, the administrative classification does not correspond exactly to the decision-making autonomy which the regions have in the different countries. To correct for this latter disadvantage, we used the NUTS 1 classes for Belgium, Germany and the UK while NUTS II is used for all other countries. Despite the disadvantages summarised above, we conclude that the NUTS classification system is the only one for which consistent data is available.

The variables which are included in the analysis should thus be direct or indirect indicators of the economic/technological system of each region. We used the European Report on Science and Technology Indicators, published by the Commission Services as a standard work to provide us with a general list of economic and technology indicators. The list was further considered to be a ‘population’ of indicators from which we selected all of them which were available for a list of regions, which is as exhaustive as possible. In table 2 a list of the variables is given which are available for each of the regions displayed in appendix 1. The reader should note that no data are available for the Netherlands and the newest EU member states: Austria, Finland and Sweden. All other countries are represented.

Table 2: Technology and economic indicators at the regional level

Name	Description
GDP	GDP per capita (constant 1990 PPS), 1995
PATENTS	Patents per capita (EPO inventions, fractional numbers), 1995
UNEMP	Unemployment rate, 1995
GERD	GERD (Gross Expenditures on R&D) as a percentage of GDP, 1995
DGDP	Change in GDP (constant 1990 PPS), 1989-1995
DPAT	Change in Patents (EPO), 1989-1995
DUNEMP	Change in Unemployment, 1989-1995
Share AG	Percentage of labour force employed in the agricultural sector, 1995

Source: EUROSTAT

GDP per head and the unemployment rate are direct indicators of a country's welfare and its labour market and are thus both indicators of its economic system. Since the unemployment rate can be seen as the result of the labour market conditions such as skill match and mismatch and wage setting, it is often used as a proxy for many environmental conditions in a region. The percentage of the labour force employed in the agricultural sector is often considered to be a structural parameter of a region's economic conditions. A high percentage of agricultural employment is often considered to be a barrier to innovation. It would be better to have a finer structural parameter such as the percentage of the labour force employed in the service sector. However, this kind of indicator is not available yet at NUTS 2 level.

Patents per capita is better known as the inventiveness coefficient (OECD) and despite all drawbacks is the most comprehensive and reliable indicator which is available to measure a region's technological output. Publications per head of population would be a good complement to measure the public research efforts of a region, but is not publicly available. GERD as a percentage of GDP is often used to represent a region or country's efforts in Science and Technology and can therefore be classified as a technology input indicator (Soete, 1981).

Despite some of the theoretical insights summarised above regarding the concepts that each of these indicators measure, many of them remain closely linked. Moreover, we do not have a correct insight into whether or not they measure different 'aspects' of a general construct such as 'the economic situation' or the 'technological system' of a region. Producing a cluster analysis based on these raw data (the eight different indicators) would therefore result in clubs of regions whose relevance would be difficult to interpret. In order to analyse whether the different raw variables are indicators of different constructs and, if so, which constructs, we performed a principal component analysis. The results of this analysis are summarised in table 3.

Table 3: Principal component analysis: factor loading (unrotated)

	Factor 1	Factor 2	Factor 3
DGDP	-,217818	-,374648	**,709854**
DPAT	,040681	**,751936**	,149687
DUNEMP	,184622	-,461744	-,634570
UNEMP	,483825	,385975	-,204824
Share AG	**-,800665**	-,282182	-,036669
GERD	**,860804**	-,052148	,129560
GDP	**,821583**	-,212738	,151084
PATENTS	**,827977**	-,265651	,120500
Expl.Var	3,059863	1,266127	1,026408
Prp.Totl	,382483	,158266	,128301

Data: DG XII-AS-4, Eurostat

As shown in table 3, a first factor which explains almost 40% of the variance in the data set is related to the regions current state of economic and technological development, including its GDP per capita, Patents per capita, GERD by GDP and the inverse ratio of its number of employees that are working in the agricultural sector.

We can call this factor the techno-economic level. One should not be surprised that indicators such as the GDP per capita and the technological input and output indicators load on the same factor. Other studies such as Verspagen (1997) have found at the country level a similar relation between US patent applications and GDP per capita in a sample of 120 countries. Somewhat more surprising is the fact that the unemployment rate is much less loaded on the first factor.

Factor 2 reflects the short-term changes in the inventiveness coefficient, while factor 3 closely reflects the changes in the economic situation. Apparently, economic growth as measured by the changes in GDP per capita and changes in technology intensity measured by the changes in the inventiveness coefficient do not necessarily co-evolve on the short term. This finding appears to be contradictory to the systemic approach, but it is not. Time lags can upset the short-term co-evolution. In Ireland for instance, economic growth due to foreign direct investment preceded the changes in R&D investment. In other high growth regions such as Islas Baleares, there is no link to the technological system at all.

The three factors together capture about 65% of the variation, which is a satisfactory percentage to serve as an input for the cluster analysis. In other words, the analysis looks for clusters of regions which are similar with respect to their level of economic/technological development and their degree of industrialisation, the short term changes in their technological system and the short term changes in their welfare. None of the regions showed outliers for any of the three factors so that each of them can be included in the analysis.

3.2 Grouping regions in similar 'clusters' of performance: Towards a typology

As aforementioned, our aim in the first part of this paper is to construct a new typology of regions. In order to form this typology, a technique should be used to classify the regions into more or less homogenous groups, based on the three factors discussed in the previous paragraph. Cluster analysis is one such tool which seems appropriate for these purposes.

Cluster analysis encompasses a number of different classification algorithms which can be classified into two broad families: hierarchical and non-hierarchical clustering. The purpose of hierarchical clustering procedures is to join objects into successively larger clusters, using some measure of similarity or distance which then results in a hierarchical tree. The method is very useful if one has no conceptual idea about the number of clusters which exist, but involves a substantial amount of arbitrariness to determine the exact number. Non-hierarchical clustering or k-means clustering on the other hand departs from the hypothesis that the researcher has an idea about the exact number of clusters. Computationally, you may think of this method as analysis of variance in reverse. The analysis starts from the k number of clusters which are defined by the research and then moves objects between those clusters with the goal to (1) minimise the variability within clusters and (2) to maximise variability between clusters (MANUAL Statistica, 1997). Ketchen and Shook (1996) suggest using both procedures as complements to each other: first a hierarchical procedure can be used as an exploratory methodology to determine the desired number of clusters as an input to the non-hierarchical step. The results of the analysis have more internal validity if both procedures classify the regions in exactly the same way. In this paper, we adopt the two-step approach suggested by Ketchen and Shook.

To perform the hierarchical cluster analysis, we used Ward's algorithm as a point of departure with Euclidean distances as linkage measures. 6 different clusters or clubs of regions could be distinguished at the 90% cut-off criterion (which proved to be the most robust). Subsequently a k-means clustering was performed using 6 as the pre-defined number of clusters. The cluster number to which each region belongs is given in appendix 1 (respectively in the first hierarchical and second, non-hierarchical, step). Two thirds of the 102 regions in the analysis were classified similarly by both procedures, leaving 30% of less robust solutions (regions marked with an asterisk in appendix 1). The descriptive statistics for each cluster are displayed in table 4, the members of each cluster are included in table 5 and can be found as well in appendix 1. For ease of interpretation, we have given each cluster a name which reflects its economic or technological position. Some of these names are inspired by Verspagen's (1997) similar cluster analysis of 118 countries.

In the period 1989-1995, regional EU can be described as falling into 6 broad categories: 8 leading regions (in terms of GDP per capita and technology). We find them back in cluster 1, labelled the *industrial leaders*; 8 regions which close the technological gap very fast. They belong to cluster 5, named the *technological catchers-up*; 4 regions which are experiencing considerable economic growth, called the *economic catchers-up*; 17 regions which are becoming isolated, both economically and technologically. For easiness, we call them the *laggers behind* and are cluster 6. Finally, we have two big groups of regions: the first group includes 36 regions which are *slow growers*. They are the third cluster in our analysis. The second group is economically and technologically one of the most advanced groups, but the 27 regions that belong to it experience very low to moderate growth rates. Therefore they are called the *clampers-on*.

Table 4: Cluster characteristics

	cluster 1 industrial leaders	Cluster 2 Clampers-on	cluster 3 slow growers	cluster 4 economic catchers-up	cluster 5 technological catchers-up	cluster 6 laggers behind
Number of Members	8	27	36	6	8	17
GDP per capita (in 1000s 1990 PPS)	21.38	15.47	13.02	9.08	11.03	9.81
Unemployment rate	10.86	8.22	2.22	3.39	3.70	13.06
PATENTS per capita	0.19	0.06	0.03	0.006	0.012	0.0016
GERD/GDP	2.55	1.55	0.84	0.54	0.84	0.34
DPAT	-0.83%	0.58%	2.98%	1.90%	23.8%	0%
DGDP	1.02%	0.59%	1.04%	4.01%	0.34%	0,4%
Share of Employment in the agricultural sector	1.95%	4.83%	8.92%	33.41%	8.56%	25%

Data: DG XII-AS-4, Eurostat

Table 4 provides more background to the characteristics which typify these regions. Note that the statistics displayed in table 4 relate to the raw data while the cluster analysis itself is performed on the three factors which result from the principal component analysis of which the results are displayed in table 3.

The ‘industrial leaders’ group (cluster 1) is excelling both at the technological and economic end. They have an average GDP per head of 21 380 ECU, which is extremely high. Six of the eight industrial leading regions are German (see table 5). Only Île de France and the Brussels region in Belgium join the list. One could compare them with the Archipelago[3] which was identified by Hilpert (1992), although some remarkable differences exist: The Archipelago was based on one single criterion, namely ‘receiving more than 20% of public R&D spending’. One sees that South East, the Italian regions and Amsterdam are missing from the list, each for various reasons. The first two because their economic situation is not yet strong enough to be classified as industrial leaders, and the last because the Netherlands is not included in the analysis due to data availability. On the other hand, some regions that did not belong to the Archipelago appear in the group of industrial leaders. Most of them are so-called ‘city-regions’, which are too small to receive over 20% of the national R&D funding, but nevertheless are leading both in technological and economic terms. Brussels is a perfect example of such a city-region.

Describing the group of industrial leaders, it is interesting to note this cluster, on average, seems to be at the summit of its technological capacity. During the last five years, the technological output has not grown. We even noticed a decrease in patent activity. On the other hand, economic welfare in each of these regions has grown at a steady rate.

Table 5: Cluster participants

Cluster 1		**Cluster 2**		**Cluster 3**		**Cluster 4**		**Cluster 5**		**Cluster 6**	
Industrial leaders		**Clampers-on**		**Slow growers**		**Economic catchers-up**		**Technological catchers-up**		**Laggers behind**	
Brussel Hoofdstedelijk gewest	B	Nordrhein-Westfalen	D	Vlaams gewest	B	Thessalia	EL	Pais Vasco	E	Galicia	E
Baden-Württemberg	D	Schleswig-Holstein	D	Région wallonne	B	Dytiki Ellada	EL	Comunidad Valenciana	E	La Rioja	E
Bayern	D	Comunidad de Madrid	E	Niedersachsen	D	Kriti	EL	Andalucia	E	Aragon	E
Bremen	D	Cataluña	E	Saarland	D	IRELAND	IRL	Abruzzo	I	Castilla la Mancha	E
Hamburg	D	Champagne-Ardenne	F	DANMARK	DK	Alentejo	P	Campania	I	Region de Murcia	E
Hessen	D	Haute-Normandie	F	Principado de Asturias	E	Algarve	P	Sicilia	I	Anatoliki Makedonia, Thraki	EL
Rheinland-Pfalz	D	Bourgogne	F	Cantabria	E			North (UK)	UK	Kentriki Makedonia	EL
Ile de France	F	Nord-Pas de Calais	F	Comunidad Foral de Navarra	E			Yorkshire and Humberside	UK	Dytiki Makedonia	EL
		Lorraine	F	Castilla y Leon	E					Ipeiros	EL
		Alsace	F	Extremadura	E					Ionia Nisia	EL
		Franche-Comté	F	Islas Baleares	E					Sterea Ellada	EL
		Aquitaine	F	Canarias	E					Peloponnisos	EL
		Midi-Pyrenées	F	Picardie	F					Valle d'Aosta	I
		Rhône-Alpes	F	Centre (FR)	F					Molise	I
		Auvergne	F	Basse-Normandie	F					Norte (P)	P
		Provence-Alpes-Côte d'Azur	F	Pays de la Loire	F					Centro (P)	P
		Piemonte	I	Bretagne	F					Lisboa e Vale do Tejo	P
		Lombardia	I	Poitou-Charentes	F						
		Veneto	I	Limousin	F						
		Friuli-Venezia Giulia	I	Languedoc-Roussillon	F						
		Emilia-Romagna	I	Attiki	EL						
		Lazio	I	Voreio Aigaio	EL						
		East Anglia	UK	Notio Aigaio	EL						
		South east	UK	Liguria	I						
		South west	UK	Trentino-Alto Adige	I						
		West midlands	UK	Toscana	I						
		North west	UK	Umbria	I						
				Marche	I						
				Puglia	I						
				Basilicata	I						
				Calabria	I						
				Sardegna	I						
				East midlands	UK						
				Wales	UK						
				Scotland	UK						
				Northern Ireland	UK						

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[3] Hilpert concluded in 1992 that R&D in Europe was concentrated in a ten “major European regions”, the so-called Archipelago: South East (UK), Île de France (F), Frankfurt (D), Munich (D), Turin (I), Rotterdam/Amsterdam (NL), Rhein-Ruhr (D), Stuttgart (D), Lyon/Grenoble (F) and Milan (I).

The ‘clamping on’ group is one which follows the industrial leaders the most closely, both technologically and economically. It is a group which includes basically the most industrialised regions in each country (see again the low share of agriculture). These regions are above average in terms of economic and technological development. On the technological side, they seem to be slowly catching up with the industrial leaders. Under the hypothesis that the technological growth rates of both clusters remain the same, it would take about 80 years before the technological gap is closed. Economically, however, they are losing ground vis à vis the industrial leaders. On average, this group is diverging from the industrial leaders, however, within the group some regions such as South East experience larger growth rates and might become members of the diverging industrial leaders.

Third, we identified a group of regions which is very close to these ‘clampers on’: the ‘slow growers’. Both economically and technologically, they are catching up with the clampers-on. Again, under the hypothesis that the growth rates remain fixed over the entire period, it would take 30 years for them to catch-up technologically with the clampers-on and 39 years to get at the same welfare level. When comparing the results of the hierarchical with the non-hierarchical cluster analysis, one sees that the difference between the ‘clampers-on’ and the ‘slow-growers’ is very fuzzy (see appendix 1). About 30% of the regions were classified differently using one procedure or the other. As a result, one could conclude that group 1 and group 2 are in a disequilibrium and certainly form a convergence club, both economically and technologically.

The ‘true’ technological and economic catch-up regions are much further from the leading countries, both in terms of GDP per capita and technological development. A first group includes the ‘economic catchers-up’. They are a rather small group of southern European regions (Spain and Portugal) and Ireland, which have recently experienced high annual growth in their economic welfare. Despite this, some of them were quite poor in 1995, although the simple average is somewhat misleading (in comparison to the cluster of ‘laggers behind’). The poorest among them is Alentejo, which has only slightly over 7000 ECU GDP per capita and the richest is Ireland with slightly under 13000 ECU GDP per capita. Interestingly, these regions have the highest percentage of their labour force employed in the agricultural sector. This is a result which is at least surprising at first sight, since this variable is often considered to be negatively correlated to a region or country’s potential for economic growth.

The second group includes the ‘technological catchers-up’. Economically, they are a bit richer than the previous group and, except maybe for Andalucia, they are only moderately agricultural. They are concentrated in Spain, Italy and the UK. Unlike the previous cluster, they mainly catch-up on the technological front. In the UK regions North and Yorkshire/Humbershire, this technological catch-up is already very prevalent. In the Spanish regions, the technological system is in an early phase of emergence. It is interesting to note that these regions belong to countries where the social capacity and, related to this, general welfare is somewhat higher. As argued by Verspagen (1997), this critical mass might be a necessity before a region can increase its technological base. Economically, they are probably those regions that would have belonged to the cluster of laggers behind, five to ten years ago.

Finally, the group of ‘laggers behind’ is identified. This group contains most of the Greek and other southern European regions. Most of these regions have a high intensity of employment in the agricultural sector. Somewhat less expected is the appearance of relatively rich Portuguese and Italian regions such as ‘Lisbon’ and ‘Valle d’Aosta’. Both regions bias upwards the ‘real welfare figure’ of the cluster. Nevertheless, because of their low technological activity and their lack of growth (both technological and economic), they belong to this cluster of the laggers behind.

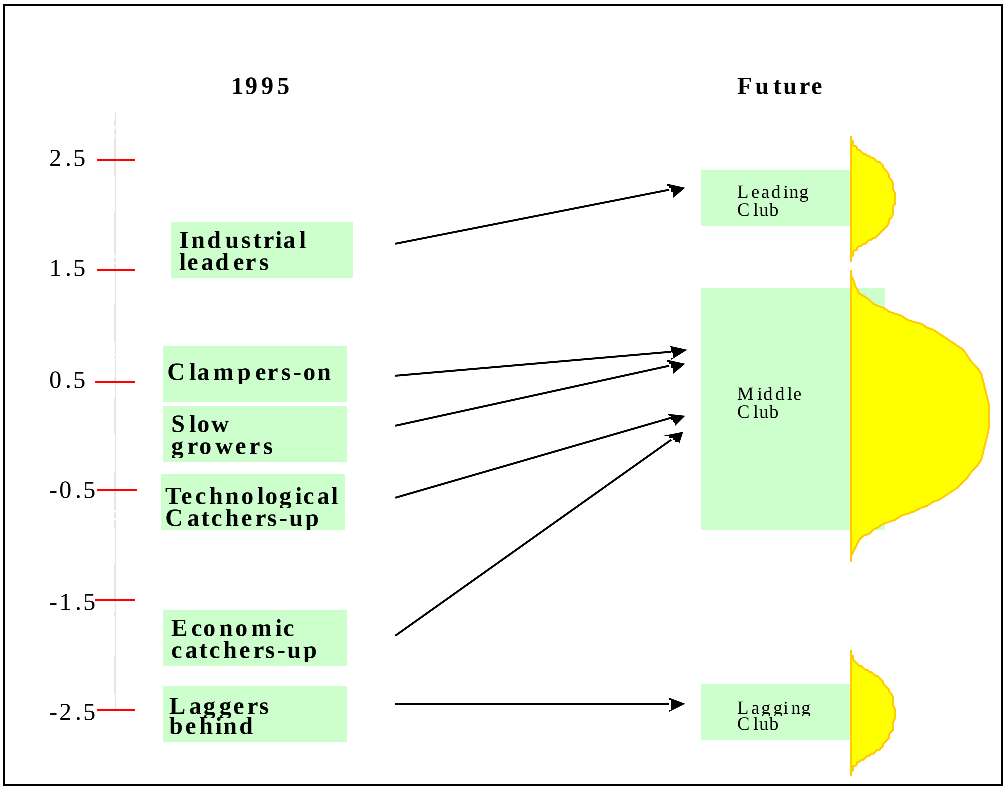
3.3 The convergence club idea.

The cluster analysis gives indirect support for the convergence club idea, launched by Baumol (1986) and elaborated at the regional level by Quah (1996, 1997), Galor (1996) and Fagerberg/Verspagen (1996). As described before, the convergence club literature states that regions or countries will not converge into one group of equally prosperous members, but probably into a number of groups. We can derive from the cluster characteristics that in the short/medium term *four* such convergence clubs exist and in the long term probably at least three of them will form a non-trivial equilibrium.

There is no economic convergence towards the ‘industrial leaders’, nor do the ‘laggers behind’ catch up economically or technologically. On the contrary, two relatively small clubs (respectively 8 and 17 regions) tend to diverge, at least economically. In the medium term (39 years if everything stays the same), we might also expect that the ‘slow growers’ will converge with the ‘clampers-on’ and hence form a big convergence club (see figure 2). Figure 2 shows the expected convergence of the different clusters. The vertical axis in the figure is the first factor of the principal component analysis (see table 2). This factor represents the techno-economic situation of the region at present.

Also the ‘economic catchers-up’ can be expected to converge at least economically. Again under the (naive) ceteris paribus assumption, it would take them only respectively 13 years to reach the welfare level of the slow growers and about 16 years to catch up with the clampers-on. This suggests that there is indeed some convergence. However, no catch up seems to take place at the technological end. The technological catchers-up experience the opposite situation. They experience a fast development of their technological system, but economically they are still at the level of the laggers behind.

Figure 2: Evolution of the 6 clusters into 3 clubs of convergence



Vertical axis: Factor 1: techno-economic dimension

One should note that the time period considered here is rather short. As aforementioned, the ‘technological catchers-up’ are mainly regions which are located in richer countries and hence can profit from the social capital (i.e. educational system, infrastructure, ...) of the whole country. This is often argued to be a big element in speeding up the technological progress in these regions (Verspagen, 1997; Capron, 1997). The economic catchers-up have a slightly different profile. They are not surrounded by such a well-developed economic environment and seemingly have first to increase their social capacity (as indicated by their growth in GDP) before they can make progress on the technological side. Ireland for instance succeeded first in attracting an increasing amount of foreign direct investment, mainly through US multinationals which located a production plant in the country, before its R&D figure started to increase.

4. The role of the EU in stimulating technology spill over between the different regional clubs

Technology diffusion and spill over are considered to play a crucial role in the catch-up process of poorer or less technologically developed regions. Scholars of the ‘technology gap’ literature (Abramovitz, 1979; Fagerberg, 1988; Verspagen, 1997) argue that relative backwardness implies an important potential for catch-up driven growth by imitation of technologies from the frontier countries. As aforementioned, this potential is dependent upon social capability (educational system, infrastructure,...) and technological congruence (match between the technologies in use in the backward and the frontier regions). In the previous part, we argued that there exists an interchange between progress in social capability and technological development (implying technological congruence). In this part we specifically focus on the role which Community technology policy plays in directing technological congruence between different clusters of regions, both directly through stimulating technological developments within regions and indirectly through the promotion of technology diffusion across regions.

4.1 Community RTD policy: The Framework Programmes

The primary objective of the Community RTD[4] policy is to strengthen the science and technology bases of its industry, enabling it to become more competitive at the international level and to promote all research actions. Further, it is defined that the Community should carry out the following activity in pursuit of the above mentioned objectives:

> *“Implementation of research, technological development and demonstration programmes by promoting cooperation with and between research centres and universities, necessary for the industrial competitiveness of the EU”*
>
> *“promotion of cooperation in Community research”*

The Single European Act (1987) clearly defines the role of the European Union in RTD policy matters, and formally outlined for the first time the basic mechanisms of current Community RTD policy including the Framework Programme, which is the general decision that defines the content, the objectives, means and priorities of Community RTD policy over five years. The Maastricht Treaty (1993) clearly stated that all RTD activities have to be decided by the Framework Programme.

Up to now, four Framework Programmes (FP hereafter) have taken place, covering the following periods: 1984-1987 (first FP), 1987-1991 (2nd FP), 1990-1994 (3rd FP), 1994-1998 (4th FP). Since the 3rd FP, a database has been constructed which contains, at the regional level, all participation in the respective FP and all RTD collaborations within and across these regions.

Regional FP participation and budget data are direct indicators of how the Framework Programme[5] influences technology developments in each of these regions. Regional RTD collaborations on the other hand can be considered as a proxy for technology diffusion and spill over. Since the third FP covers most of the period for which we collected regional indicators (1989-1995) it can thus be seen as directly related to the influence on the shape and direction of these collaborations.

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[4] Research and technological development

[5] In addition to the Framework Programme, the Structural Funds provide a second main instrument for the European Commission to stimulate R&D development in the regions. No regional data are however available regarding this Fund.

4.2 Regional RTD participation in the Third Framework Programme: How does EU RTD policy stimulate technological catch-up?

Looking again at the clusters which were calculated in the previous part of this paper, we show in table 6 some of the key technology indicators regarding their FP participation rates. As expected, the industrial leaders (only 8 regions) are the main players in the programme. Although they represent less than 20% of the total GDP, they stand for 44.8% of all European patent applications and 35% of all participation in the Third Framework Programme. Despite this 10 percentage points difference, we could not conclude that this is statistically significant (p=0.35). Hence, it might be due to the random variation of participation totals in the 3rd FP. Their share in the FP budget is even larger since each of the leading industrial leaders receives a substantially larger budget than the other regions. As a result, one might conclude that their budget share is very close to their real share of Europe’s technological activity. In this sense, European technology policy reflects very closely the technological strengths of the leading regions, which is not surprising since it is mainly a bottom-up, competitive selection process based on excellence.

In relative terms, the ‘laggers behind’ and ‘catchers-up’ benefit most from the 3rd FP compared with their share of patents. In the group of the ‘laggers behind’, the participation share in the 3rd FP is 3.77% and their patent share is only 0.11%, a difference which is statistically significant (p<0.01). Therefore, we can conclude that the Third Framework Programme really favours technological development in this group. The ‘technological catchers-up’ receive almost double their share in patents (1.49% vs. 3.72%), but this percentage difference is not significantly different from 0 (p=0.17) and can thus be caused by random errors. Finally, the group of ‘economic catchers-up’ seems to be favoured (0.53% vs. 3.25%). Despite this seemingly large difference, we have no evidence that the 3rd FP systematically favours them (p=0.35). On the other hand, the groups of ‘clampers-on’ and ‘industrial leaders’ appear to lose some of their share, but again we have no statistical support to conclude that this is a systematic loss and not a random error. The existing regional technology competencies are confirmed and enforced by the Framework Programme.

Table 6: Framework Programme characteristics
(only the 102 regions are included in the totals)

	cluster 1 industrial leaders	**cluster 2 clampers-on**	**cluster 3 slow growers**	**cluster 4 economic catchers-up**	**cluster 5 technological catchers-up**	**cluster 6 laggers behind**
% of all regions	7.85%	26.5%	35.2%	5.88%	7.85%	16.7%
% of GDP	19.9%	42.9%	23.8%	1.46%	7.80%	4.06%
% of Patents	44.8%	37.9%	15.1%	0.53%	1.49%	0.11%
% of total participation in FP3	35.3%	33.9%	21.0%	3.25%	3.72%	3.77%
average budget	224976	49385	20971	18050	15485	6466
cluster connectedness	73%	59%	49%	43%	57%	33%
cluster density	100%	78%	43%	40%	71%	17%
avg intra-regional coll.	80	46	23	8	13	5
avg centrality position	0.011	0.009	0.007	0.006	0.008	0.0045
st. dev. of centrality	0.001	0.002	0.003	0.003	0.001	0.0038

Data: Commission Services, DG XII-AS-4.

5. Technology diffusion in the Framework Programme: A Network Analysis

The second set of descriptive statistics relates to the collaboration position which each of these regions occupies in the FP network. To analyse this position, we use a set of techniques which are developed in the social network literature (Burt, 1980; Freeman, 1979). The social network measures can be divided into two categories according to their level of analysis. A first category is called *relational* network indices and is used to describe the intensity of relations between pairs of actors. The second category is usually labelled *positional* indices and indicates the network position that a particular actor (in this case a region) holds in the network.

5.1 The Positions of Clusters and Individual Regions in the Framework Programme

The most simple of this first category of indicators is ‘cluster connectedness’. This is calculated as the sum of the contacts which all regions that belong to a certain cluster have with the regions *outside* the cluster[6] divided by the total number possible. The result is a percentage which shows the cluster connectedness in the entire regional network. As expected, the ‘industrial leaders’ are the most connected cluster in the network. More interesting, however, is the observation that the ‘technological catchers-up’ almost equals the group of ‘clampers-on’ in terms of network connectedness. This means that European RTD policy in general and the Framework Programme in particular are important vehicles of technology adoption in these ‘catching-up’ regions, even more so than in the group of slow growers and economic catchers-up. The reader should also note the relative unimportance of the laggers behind. In this group, only a limited number of regions collaborate with an even more limited number of regions outside (and inside) the cluster. One could hardly conclude here that there is a significant process of technology diffusion for these regions.

‘Cluster density’ on the other hand is a relational network measure which indicates the cohesion of a network inside the cluster (Burt, 1980). It is calculated as the amount of contacts that each region in the cluster has with other regions *within* the cluster divided by the total number of such contacts possible in the cluster[7]. One immediately

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[6] Formally, the index is constructed as follows:

Cc_k is the connectedness of the cluster k, which is the sum of all the c_{ij} between the regions in the cluster and the regions extra-cluster, divided by the maximum possible : $N_k*(N-N_k)$

$$Cc_k = \frac{\sum_{i \notin Clust.k} \sum_{j \in Clust.k} (c_{ij})}{N_k * (N - N_k)}$$

[7] Formally, the index is constructed as follows:

c_{ij} = 1 if one or more collaborations exist in-between the two regions
= 0 otherwise

N is the total number of the regions within the clusters. N = 102.
N_k is the number of regions in the cluster k.

Cd_k is the density of the cluster k, which is the sum of all the c_{ij} between the regions in the cluster (except the c_{ij} intra-regions), divided by the maximum possible: $N_k*(N_k-1)$.

sees the strong cohesion in the cluster of the industrial leaders. Each of these leaders has contacts with one another so that we can speak of a completely connected subgraph. The cluster density is also high for the group of clampers on and technological catchers-up. Again, we can conclude that EU RTD policy plays a role for these regions. At the other extreme, one can see how the group of laggers behind is very scarce in its network contacts.

As aforementioned, a second category of indicators is normally used to describe the individual network position of each actor. A first such index, the centrality measure, is a proxy for the average centrality of each region. Freeman (1977) distinguishes between three types of centrality indicators based on degree, closeness and betweenness. To keep things simple, we only calculate here the degree centrality (which is the most important in a symmetric graph). A region is considered to be more central than others if it collaborates with more regions than all others do. To correct for the 'quality' of the actors with which any region collaborates, we weighed the centrality index against the centrality position of each actor with which the region had contact[8].

To aggregate this regional index at the cluster level, the cluster average and standard deviation were calculated. The averages tell more or less the same story as the relational indices. The small standard deviations in the groups of 'industrial leaders' and 'technological catchers-up' indicate that in both groups each participant occupies a similar place in the network. Because the centrality indices are very skewed towards the 'industrial leaders', which are almost always involved in any FP proposal, it is interesting to construct a rank order of the centrality index. Figure 3 gives a graphical presentation (box plot) of these centrality rankings for each cluster.

$$Cd_k = \frac{\sum_{i \in Clust.k} \sum_{j \in Clust.k,\, j \neq i} (c_{ij})}{N_k * (N_k - 1)}$$

[8] Formally, the centrality index is constructed as follows: $c_{ij} = 1$ if one or more collaborations exist in-between the two regions
= 0 otherwise

The weight of the region j, called w_j, is the sum of all the binary indicators in the row (j), divided by the maximum of these sums (the weights being always between 0 and 1).

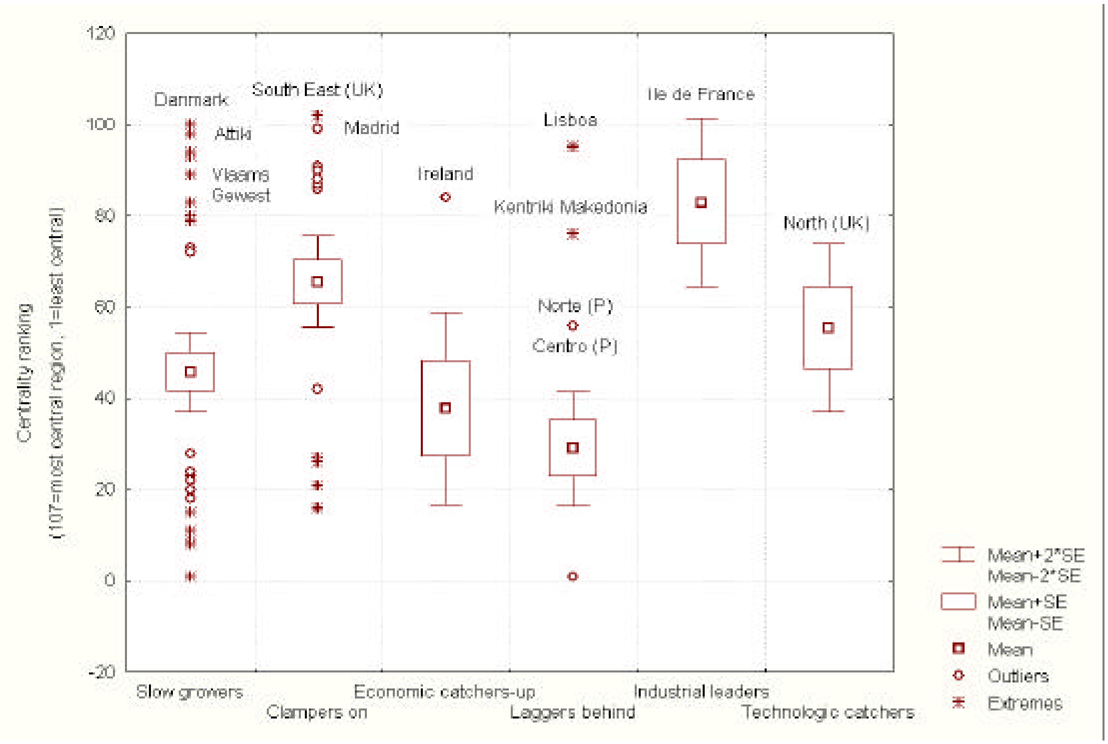
$$w_j = \frac{\sum_i c_{ij}}{\max_j (\sum_i c_{ij})}$$

The weighted centrality itself, for the region j, called p_j, is the sum of the weights of all the regions who with the region j collaborate, divided by the total of all the sums.

$$p_j = \frac{\sum_i (c_{ij} . w_i)}{\sum_j (\sum_i (c_{ij} . w_i))}$$

So the sum $\sum p_j$ equals 1.

Figure 3: The ranking of FP centrality



Data: DG XII, Commission Services

Appendix 1 gives more detailed information on the individual ranks each region occupies. Although each of the 'industrial leaders' has a very central position, they rank not from 1 to number 8. Instead, among the ten most centrally positioned, we find *South East (London)* at number 1, *Denmark* at number 3, *Communidad de Madrid* at number 4, *Attiki* at number 5, *Lisbon* at number 8, Vlaams *Gewest* at number 9 and, finally, *Scotland* at number 10. None of these regions is currently an 'industrialised leader'. On the contrary, Lisbon even belongs to the group of economic catchers-up. The prevalence of the 'most prosperous' Southern European regions as central actors in the Framework Programme is astonishing. In the next section of this paper, we will further analyse whether the participation of these regions diffuses RTD from them to the local economies of their countries.

The centrality ranks might also be considered as an indicator of each region's potential to improve its position on the techno-economic dimension. For instance, it is clear that North (UK) is very active as a participant in the Framework Programme and probably can benefit from this programme to stimulate its technological capability. Other examples are Lisboa, Kritiki Makedonia, Norte (P) and Centro (P), which are each outliers in the group of laggers behind. In the group of slow growers one also sees the amazingly central position of Attiki, Denmark and Vlaams Gewest, which each seem to be on their way up.

At the cluster level however, the average position of the 'technological catchers-up' is also interesting. Their median rank is almost as high as the one of the clampers-on. Furthermore, the region with the least centrality rank is still quite central and the ranking difference within the cluster is not extremely high. This again confirms our predisposition that the FP is quite important in stimulating technology diffusion towards these catchers-up.

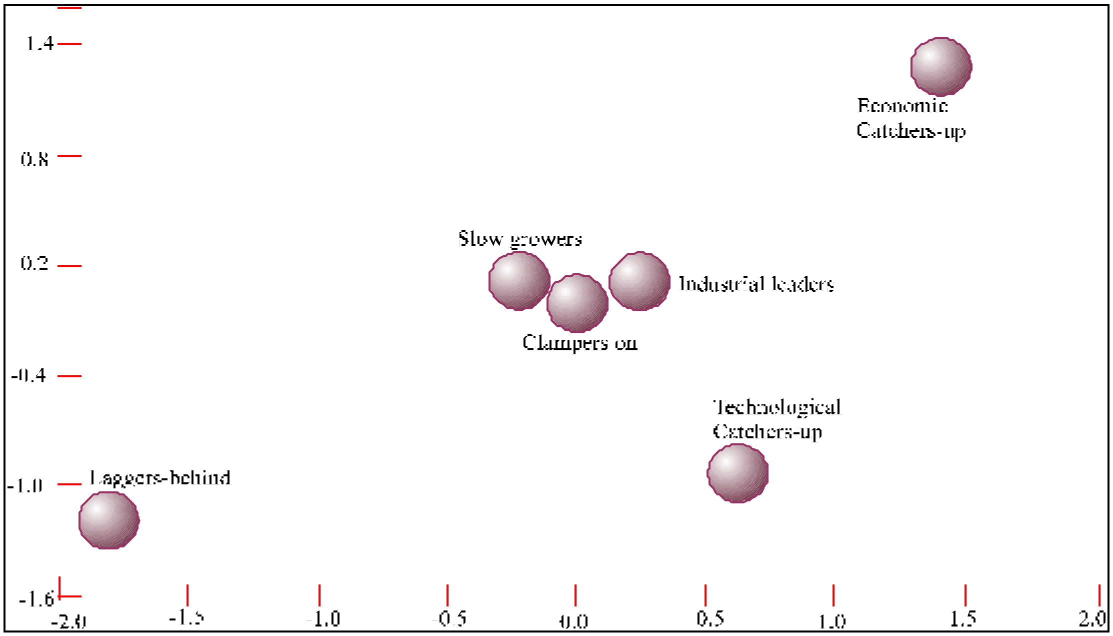
5.2 A Structural Analysis of the Framework Programme Collaboration Patterns

In the previous section, we looked at some descriptive network indicators which give an idea of the collaboration intensity of each region or cluster. We will now look inside each network and analyse its structure in order to obtain an insight into how technology diffuses among the different partners of the network.

To do so, we created a submatrix of collaborations among the regions in each cluster. These matrices were analysed as proximity matrices and displayed through the use of multidimensional scaling techniques (see figures 4 and 5). The nodes in each of the figures represent the regions. The more central the regions are placed on the MDS map, the more central they are in the actual network. The closer they are located next to each other, the more similar their network position is. The concept is similar to that of ‘structural equivalent regions’. Burt (1991) has shown that structural equivalent actors in a network tend to mimic or adopt each other’s technology. Hence, the closer a region is situated next to another region, the more intensive its technology diffusion pattern. In order to distinguish between different diffusion classes within each network, a non-hierarchical k-means cluster analysis was performed to classify the regions in a maximum of four equivalent classes of technology diffusion.

The networks in the cluster of ‘laggers behind’ and the ‘technology catchers-up’ are not shown. In the case of the ‘laggers behind’ and ‘technology catchers-up’ the intra-cluster network was so dispersed that one could not really speak of a network with technology diffusion classes. Therefore, we left them out of the structural analysis.

Figure 4: Structure of the FP 3 Network



Data: DG XII, Commission Services

Figure 4 shows the position of each cluster in the overall network. One can see that technology diffusion in FP3 encourages technology diffusion among the ‘industrial leaders’, ‘slow growers’ and ‘clampers-on’. They are, as to be expected in the middle of the FP3 network. Further, although the technology catchers-up have many contacts with regions of other clusters, these contacts are not very repetitive and result in only a few collaborations. Therefore, technology diffusion remains rather limited in the overall picture. An equal observation can be made for the economic catchers-up although the intensity of technology diffusion among them is even worse. Finally, one clearly observes that the ‘laggers behind’ fall out of the picture.

Let us now take a closer look at technology diffusion within each of the three central clusters (figures 5a-d). As aforementioned, the cluster of ‘industrial leaders’ is very dense and well connected. Île de France (FR1) holds the central position in this group of regions. The presence of French enterprises such as Thomson and Aérospatiale is partly responsible for this. The region also closely collaborates with Bayern (DE2) and Baden-Württemburg (DE1). Its strong links with Bayern can be traced back to the Airbus consortium in which BMW participates. The third major participant, British Aerospace, is not located in a region which is an ‘industrial leader’. Otherwise, we would also find this region (East Anglia) in the centre of the figure. Another part of the explanation lies in the fact that the big city regions such as “Île de France” host many coordination centres of large enterprises, which also are the contacts with the European Commission, so that their network position is biased.

The black arrows further indicate that each of the regions from which the arrow departs has at least 20% of its collaborations with the region to which the arrow points. Again we see that most regions closely collaborate with Île de France and even are dependent upon it. The red arrows show 10% dependence. In this case Bayern (DE2), Baden-Württemburg (DE1) and Brussels (BE1) turn up as local centres of mutual collaboration. Concerning the technology diffusion debate, one can conclude from this that technology diffuses intensively among the industrial leaders.

Figure 4b shows the relatively central position of Ireland and Dytiki Ellada in the group of economic catchers-up. Both regions have started to increase their technology potential quite recently. Compared to the other clusters, this is a very scarce network. This is not surprising, since these economic catchers-up, like the technological catchers-up, tend to collaborate most with the industrial leaders.

The cluster of ‘slow growers’ however, shows a very different structure (figure 5c). Here, we find a very dense network centre including ‘Vlaams Gewest’ (BE2), ‘Attiki’ (GR3), ‘Denmark’ (DK), ‘Scotland’ (UKA) and ‘Niedersachsen’ (DE9). The dense centre of network cooperation and technology diffusion has a very international character with regions coming from as many as five different countries spread geographically through Europe. The second, less connected, layer (grey colour) remains international in character. The third layer (green colour) is widely scattered around. Furthermore, one clearly finds regional subgroupings of the same countries. For instance, we find an Italian, Greek, Spanish and French zone in the picture. Furthermore, once outside the second layer, very little technology diffusion takes place. The regions are scattered around in subnational groupings.

Figure 5a: “Industrial leaders”

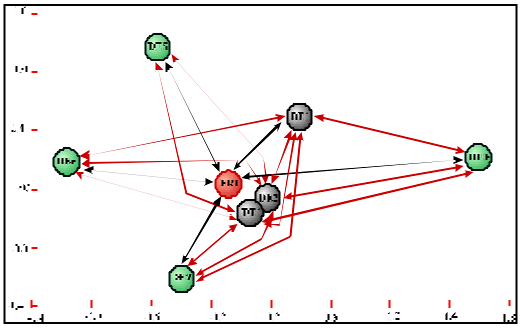


Figure 5b: “Economic catchers-up”

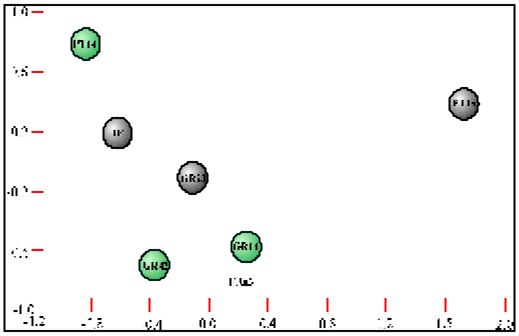


Figure 5c: “Slow growers”

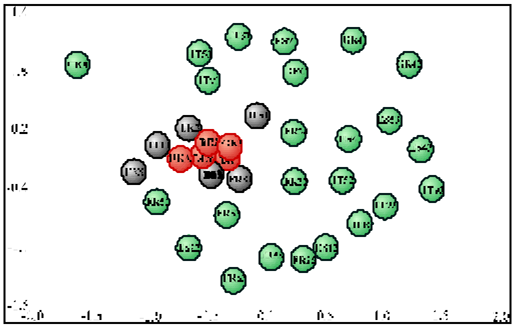
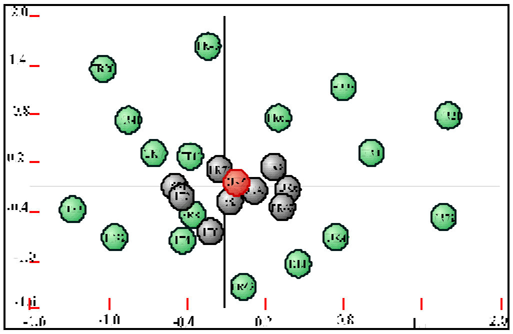


Figure 5d: “Clampers-on”



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In the centre of the ‘clampers on’ network (figure 5d), we find again a dense clique of regions such as East Anglia (UK5), Madrid (ES3), Nordhrein-Westfalen (DEA) and Lazio (IT6). As in the network of ‘slow growers’, these regions form a very international technology adoption category. In the second layer, we find a quite dense category of internationally collaborating regions. Both first and second layer are larger in this network than in the network of the slow growers, which means that we can conclude that this network is more densely connected. This is not surprising since the regions that participate in it are more ‘mature’ and further developed than in the previous case. Interestingly, the third layer of regions contains almost all French and Italian regions of the network. This Franco-Italian layer profits the least from the FP technology efforts.

6. Conclusion and Policy Recommendations

In this paper, we analysed the economic and technological disparities among the different regions in the EU. In line with the systemic view, we concluded that the economic and technological parameters co-evolve over the long term. Therefore, we could not statistically detect any regions which were performing very well on one dimension and very badly on the other. However, short term evolutions in technological development and increases in economic welfare may differ. Some regions can be classified explicitly as ‘technological catchers-up’, while others are ‘economic catchers-up’.

We could categorise Europe into six groups of regions which resemble each other in technological and economic terms. This classification allows us to conclude that, although on average the technology and economic gap is decreasing, the gap between the ‘industrial leaders’ and the ‘laggers behind’ is gradually increasing, both from the technological and from the economic point of view. Further, the decrease in the technology gap attributable mainly to the ‘slow growers’ catching up with the ‘clampers on’. On the other hand, the ‘clampers on’ do not appear to be catching up with the ‘industrial leaders’. This suggests that, in the long term despite its policy of favouring balanced regional growth, Europe is evolving towards a state in which a small group of regions dominates the economic and technological landscape. However the majority of regions form a large cluster of averages. Finally, about 15% of the regions lag behind.

From a policy perspective, it is interesting to note that despite recent efforts in the Structural Funds, we cannot conclude that the lagging behind regions tend to converge economically with the more economically advanced regions. The lagging behind regions do not seem to have any absorptive capacity at all, and it is therefore questionable whether they can benefit from a vehicle such as the Framework Programme. Of course, this Programme serves the objective of reinforcing Europe’s technological competence, and not of diffusing technology towards areas that lag behind technologically. This is clearly reflected in the network position they take in the Programme: they are at the periphery, where little knowledge diffuses. Since few patents are taken in these regions, we can even question the existence of an industrial structure. Even classic industrial policy instruments might be too weak to stimulate economic growth in these regions. However, some of them might possess distinct competitive advantages in terms of location which can increase their attractiveness for private investors. A novel policy might be developed to stimulate this.

On the other hand, the clusters of catching-up regions might benefit from policy actions that are oriented towards technology diffusion (technological catchers-up) or the creation of additional social capability (economic catchers-up). This latter cluster has increasingly developed an industrial structure, which is likely to become involved in industrial research, although their patent position is still rather weak. The regions might need a public/private R&D capacity which can help industry to develop its research interests. The technological catchers-up, however, experience growth in their RTD base, though seem still to lack the commercial effects. Here, some classic industrial policy might be needed to help the commercialisation process. Because the situation of each cluster is so specific, the initiatives might preferably be regionally based.

Most regions in the hybrid clusters of clampers-on and slow growers are not to be considered technology leaders but are situated just below them. On average they are thus not at the leading edge of technological advance (although some of them might be leading in a specialised niche), but they clearly play a crucial role in the EU economy as engines of progress. Facing problems of industrial competitiveness (as reflected in the relatively high unemployment rate) and efficiency, they might be in need of a clear innovation oriented policy (slow growers/clampers-on). New forms of financing mechanisms such as electronic stock quotations (Easdaq, Le nouveau marché,...), the various risk capital mechanisms (EVCA, investment banking) and specific initiatives aimed to increase the entrepreneurial culture and innovation in SMEs can be part of such an innovation policy (Chabbal, 1995). EU innovation policy might play an important role in coordinating initiatives in the financial market through the formation of a European Investment Bank or even, indirectly, through the single market which creates an enormous potential for a stock market such as EASDAQ. In contrast, it might be extremely difficult for an international policy organism to be actively involved in regional actions aimed at creating a fertile ground for start-ups.

Finally, the industrial leaders are at the cutting edge of technology. On average, the companies in these regions determine the technological competitiveness of the EU. An EU policy instrument such as the Framework Programme is therefore expected to be extremely interesting for them. As noted already by Hilpert (1992), the RTD institutes in these leading regions, be they public or private, tend to form RTD consortia which aim to handle with technological complexity and cost. Traditional RTD policy instruments that directly sponsor initiative in emerging technology domains might be extremely important in this respect.

In the second part of the paper, we analysed to what extent the different sets of regions participated in the 3rd Framework Programme and thus how the existing main RTD policy instrument available in the Commission influences technology development and diffusion in Europe. Concerning technology development, we can conclude the EU RTD policy reinforces the existing technological competencies, which is to be expected, through a competitive bottom-up selection of the various proposals. Those that are the strongest profit most, those that are somewhat weaker profit less. Although there exist some differences, these could be explained by random errors. Only the laggers behind seem to receive significantly more support from the Framework Programme than their current technological capacity. One could think of a number of reasons to explain this. For one thing, we included only the enterprise sector (patents) in our analysis, while the Framework Programme gives a substantial amount of money to the higher education sector and the various government based research centres as well. Hence, most of the direct technology support may go to the research centres. Another explanation is more policy related: as argued by Landabaso (1995), among others, the technology policy of the late eighties and early nineties has been to subsidise large prestigious research centres in lower developed countries. The problem with these research centres seems to have been their lack of technology diffusion.

This problem is also confirmed in our network analysis. Although the EU does not seem to change the pattern of technology development, it plays a significant role in technology diffusion patterns. The most visible result was the benefits that go to the group of the ‘technological catchers-up’. Equally surprising was the absence of diffusion to the laggers behind, despite their relatively active participation in the Framework programmes.

Furthermore, both the network indices and the cluster analysis show the importance of big cities or ‘city-regions’ in the European economic and technological landscape. Most of the industrial leaders in Europe are big cities such as London, Paris, etc... These cities form the ‘core axis’ of regional Europe. It is important to note as well that, although most of them are German, they are very international in nature. In the centre of each network, we find a very international regional core with an emphasis on industrialised cities. This finding is very contradictory to the idea of national innovation systems. Advanced regions seem to collaborate and diffuse technology in a very multinational or international way.

The national, or maybe better, the local dimension comes more into the picture in the less technology intensive or peripheral network regions. The question which arises here however is: if the national dimension does not play a significant role in explaining technological collaboration, what then are the main drivers behind such a system?

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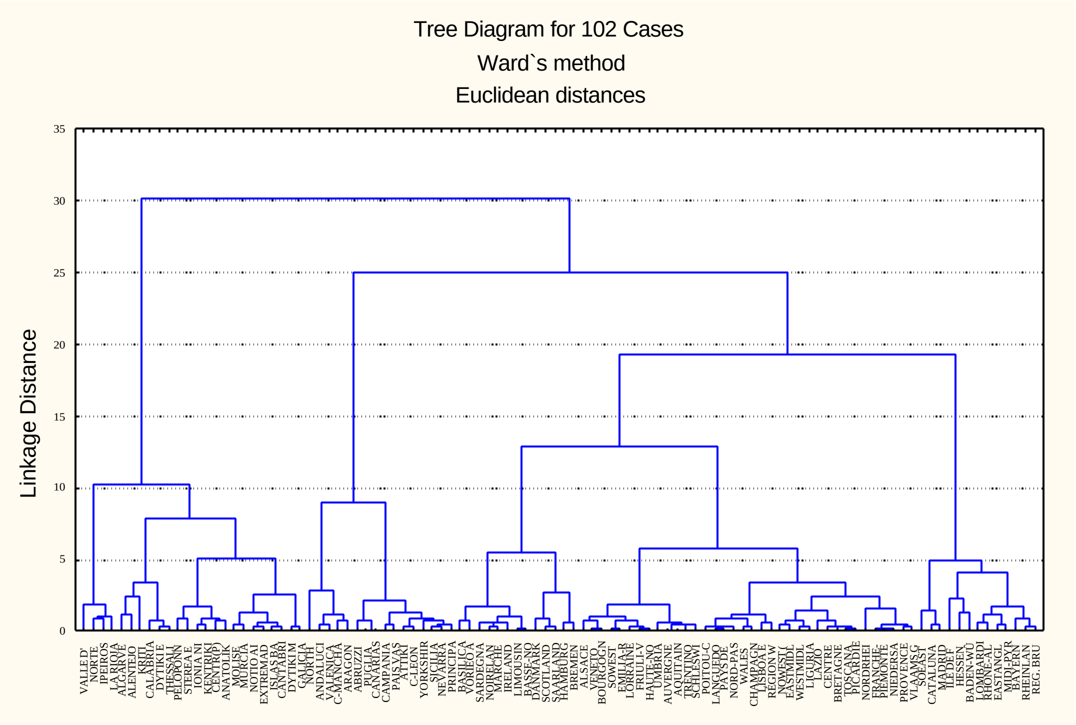
Appendix 1

Nomenclature		non-hierarchic	hierarchic	robustness	Ranks on weighted centrality
BE1	Brussel Hoofdstedelijk gewest	1	1		11
BE2	Vlaams gewest	3	2	*	9
BE3	Région wallonne	3	2	*	20
DE1	Baden-Württemberg	1	1		7
DE2	Bayern	1	1		6
DE5	Bremen	1	1		44
DE6	Hamburg	1	1		29
DE7	Hessen	1	1		22
DE9	Niedersachsen	3	2	*	14
DEA	Nordrhein-Westfalen	2	2		13
DEB	Rheinland-Pfalz	1	1		39
DEC	Saarland	3	2	*	72
DEF	Schleswig-Holstein	2	3	*	41
DK	DANMARK	3	4	*	3
ES11	Galicia	6	6		69
ES12	Principado de Asturias	3	3		67
ES13	Cantabria	3	3		85
ES21	Pais Vasco	5	5		51
ES22	Comunidad Foral de Navarra	3	3		66
ES23	La Rioja	6	6		99
ES24	Aragon	6	6		68
ES3	Comunidad de Madrid	2	2		4
ES41	Castilla y Leon	3	3		71
ES42	Castilla la Mancha	6	6		93
ES43	Extremadura	3	3		94
ES51	Cataluña	2	2		16
ES52	Comunidad Valenciana	5	5		56
ES53	Islas Baleares	3	3		92
ES61	Andalucia	5	5		35
ES62	Region de Murcia	6	6		60
ES7	Canarias	3	4	*	80
FR1	Ile de France	1	1		2
FR21	Champagne-Ardenne	2	3	*	87
FR22	Picardie	3	3		62
FR23	Haute-Normandie	2	3	*	61
FR24	Centre (FR)	3	3		43
FR25	Basse-Normandie	3	4	*	83
FR26	Bourgogne	2	3	*	77
FR3	Nord-Pas de Calais	2	3	*	57
FR41	Lorraine	2	3	*	48
FR42	Alsace	2	3	*	46
FR43	Franche-Comté	2	2		82
FR51	Pays de la Loire	3	3		54
FR52	Bretagne	3	3		45
FR53	Poitou-Charentes	3	3		63
FR61	Aquitaine	2	3	*	37
FR62	Midi-Pyrenées	2	2		21
FR63	Limousin	3	4	*	88
FR71	Rhône-Alpes	2	1	*	12
FR72	Auvergne	2	3	*	76
FR81	Languedoc-Roussillon	3	3		30
FR82	Provence-Alpes-Côte d'Azur	2	2		25
GR11	Anatoliki Makedonia, Thraki	6	6		84
GR12	Kentriki Makedonia	6	4	*	27
GR13	Dytiki Makedonia	6	6		99
GR14	Thessalia	4	4		86
GR21	Ipeiros	6	6		64
GR22	Ionia Nisia	6	4	*	96
GR23	Dytiki Ellada	4	4		52
GR24	Sterea Ellada	6	6		91
GR25	Peloponnisos	6	4	*	99
GR3	Attiki	3	3		5
GR41	Voreio Aigaio	3	3		95
GR42	Notio Aigaio	3	3		99
GR43	Kriti	4	4		55
IE	IRELAND	4	4		19
IT11	Piemonte	2	2		32
IT12	Valle d'Aosta	6	6		98
IT13	Liguria	3	2	*	53
IT2	Lombardia	2	1	*	18
IT31	Trentino-Alto Adige	3	3		70
IT32	Veneto	2	3	*	42
IT33	Friuli-Venezia Giulia	2	3	*	50
IT4	Emilia-Romagna	2	2		33
IT51	Toscana	3	3		23
IT52	Umbria	3	3		73
IT53	Marche	3	3		81
IT6	Lazio	2	3	*	15
IT71	Abruzzo	5	5		78
IT72	Molise	6	6		97
IT8	Campania	5	5		36
IT91	Puglia	3	3		65
IT92	Basilicata	3	4	*	74
IT93	Calabria	3	4	*	79
ITA	Sicilia	5	5		58
ITB	Sardegna	3	4	*	75
PT11	Norte (P)	6	6		47
PT12	Centro (P)	6	4	*	49
PT13	Lisboa e Vale do Tejo	6	5	*	8
PT14	Alentejo	4	4		89
PT15	Algarve	4	4		90
UK1	North (UK)	5	5		28
UK2	Yorkshire and Humberside	5	5		38
UK3	East midlands	3	2	*	24
UK4	East Anglia	2	2		40
UK5	South east	2	2		1
UK6	South west	2	2		17
UK7	West midlands	2	2		34
UK8	North west	2	2		26
UK9	Wales	3	3		31
UKA	Scotland	3	2	*	10
UKB	Northern Ireland	3	4	*	59

Appendix 2


Tree Diagram for 102 Cases
Ward`s method
Euclidean distances
Linkage Distance
35
30
25
20
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5
0
VALLE D'
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KRITI
CALABRIA
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EXTREMAD
ISLAS BA
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C-MANCHA
ARAGON
ABRUZZI
PUGLIA
CANARIAS
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PAIS VAS
ATTIKI
C-LEON
YORKSHIR
SICILIA
NEVARRA
PRINCIPA
BASILICA
VORIEO A
SARDEGNA
NOIRELAN
MARCHE
IRELAND
LIMOUSIN
BASSE-NO
DANMARK
SCOTLAND
SAARLAND
HAMBURG
BREMEN
ALSACE
VENETO
BOURGOGN
SOWEST
EMILIA-R
LORRAINE
FRIULI-V
HAUTE-NO
UMBRIA
AUVERGNE
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RHEINLAN
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