## SCIENCE AND TECHNOLOGY IN THE FUNCTIONAL URBAN REGIONS IN NORTHWEST EUROPE

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#### FOREWORD

This study was conducted in the framework of the GEMACA II project (Group for European Metropolitan Areas Comparative Analysis, second project), which addresses the competitiveness of the major metropolitan areas in Europe.

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#### **General Introduction**

In an economy where knowledge is becoming increasingly important (OECD, 2000), science and technology stimulate economic development, job creation, the improvement of products and services as well as public health initiatives.

Such activities are principally concentrated in the economies of industrialised companies, where they play a fundamental role in the economy of major metropolitan areas such as Paris, London, Los Angeles and Tokyo. In fact,  $\frac{3}{4}$  of the international community's investment in research and development<sup>1</sup> is made in North America (37 %), Europe (28 %) and industrialised Asian countries (20 %). However, these three groups of countries represent only 61 % of the world's GDP and less than  $\frac{1}{4}$  of the global population.

	GERD Global share	GDP Global share	Population Global share
Europe	27.8%	22.7%	8.8%
CIS	1.2%	3.0%	4.9%
South Mediterranean	1.5%	3.6%	3.9%
North America	36.7%	22.5%	5.1%
Latin America	3.6%	8.8%	8.4%
Sub-Saharan Africa	0.5%	2.4%	10.4%
Industrialized Asian countries	20.2%	15.6%	9.5%
China	4.3%	12.6%	21.2%
India	2.1%	3.9%	16.6%
Other Asian countries	0.9%	3.5%	10.8%
Oceania	1.2%	1.3%	0.5%

#### Chart 1: Scientific and Economic Weight of the World's Major Geographic Areas in 1996

Industrialised Asian countries: Japan, Taiwan, Singapore, South Korea, Indonesia, Malaysia, Philippines and Thailand.

South Mediterranean: Israel, Algeria, Egypt, Lebanon, Libya, Malta, Morocco, Syria, Tunisia and Turkey.

Source: OECD data (principal S&T indicators), UNESCO and INED, OST processing and forecasts, 2000

Scientific and technological resources are very unevenly distributed, even in OECD member countries. The European Union, which represents a hefty 28 % of the area's spending in research, is a major player between the United States (43 %) and Japan (18 %).

 $<sup>^{1}</sup>$  Gross domestic expenditure on research and development (GERD) that represents overall spending associated with R&D (capital and standard spending) whatever the source of the funds.



Source : OECD, 2000

#### 1. Science and Technology in Europe

Second only to the United States in the fields of science and technology, the states and regions of the European Union are disproportionate.

#### 1.1. Science and Technology in Europe

In 1998, R&D expenditure in the European Union was estimated by Eurostat to be at 141 billion Ecus, or approximately 70 % of similar research in the United States (202 billion Ecus), and higher than Japan's investment (102 billion Ecus). Compared to the GDP, research in the European Union in 1998 (1.86 %) is significantly lower than that of the United States (2.58 %) and Japan (3.03 %). Such disparities are essentially attributed to the business enterprise sector, where R&D expenditure in the European Union is far less than in the United States and Japan.

Europe is disproportionate because Germany (30.8%), France (19.8%), the United Kingdom (16%) and Italy (7.5%) represent <sup>3</sup>/<sub>4</sub> of the investment in research of all 17 countries in the European Economic Area (E.E.A.).



Such disparities are also observed through other indicators, such as registered patents, the R&D intensity, research personnel and scientific publications.

	Patents registered in Europe (1999)	R&D spending in % of GDP (1998)	R&D personnel in % of working population (1998)	Global share of scientific publications (1998)
Germany	43.6	2.29	1.48	6.8
France	14.9	2.19	1.51	5.2
U. K.	12.3	1.82	1.28	8.2
Italy	7.5	1.02	0.81	3.5
The Netherlands	5.5	2.04	1.44	2.1
Sweden	4.7	3.77	2.36	1.6
Finland	2.7	2.89	2.43	0.8
Belgium	2.7	1.84	1.22	1.0
Austria	2.2	1.80	1.16	0.7
Denmark	1.6	1.93	1.99	0.8
Spain	1.6	0.51	1.02	2.4
Others	0.8	n.s	n.s	0.9

**Chart 2: Science & Technology in European Countries (in %)** 

Source: Eurostat, O.E.B, O.S.T, processed by the Iaurif, 2001

#### 1.2. Resources in European Regions

The above disparities are even more apparent on a regional level.

Regional economic investment in science and technology is measured according to Gross domestic expenditure on R&D (GERD) that reveals the total spending associated with R&D regardless of the source of the funds. Despite the geographical division (NUTS division, 1995), Eurostat data gives an initial picture of a high concentration of research in certain European regions, since eight of them represent over half of Europe's GERD.





Ile-de-France ranks among the leading regions in Europe in research and development, having invested over 11 billion Ecus in 1996. It concentrates nearly 11% of Europe's economic resources in R&D, ahead of the regions of Bade Württemberg (NUTS 1), Bavaria (NUTS 1), the Southeast (NUTS 1) and Rhein-Ruhr (GEMACA).

An evaluation of R&D expenditure per type of institution illustrates several organizational models for science and technology in European regions.

- in most regions, research is primarily conducted in business enterprises. In fact, companies carry out 62% of R&D in the European Union. This is particularly true for Ilede-France, Bade Württemberg, Stockholm, Milan, Rhein-Main, and Bavaria, where research in the industrial sector largely exceeds the European average
- regions that report equal spending in industrial, public and academic research, such as Madrid, Brussels and London
- regions where research is primarily conducted in universities or public institutions, such as Randstad-Holland (60% of spending is made in non-industrial sectors) and Berlin (59%)

A clearer geographical assessment of R&D in Europe can be made from the data available in European patents and scientific publications.



Data ISI ( SCI, COMPUMATH ) processed by OST and IAURIF, 2001

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## 2. Scientific Performance of Functional Urban Regions in Northwest Europe

The scientific performance of European regions was evaluated according to the number of scientific publications calculated by the french Observatory of Science and Techniques (OST),<sup>2</sup> based on the database of the Science Citation Index (see annex).

#### 2.1 The Scientific Performance of Major European Regions

One of the first elements the chart reveals is that science in Europe is concentrated in a few major multidisciplinary scientific regions, as well as some small and medium-sized poles. The first 15 regions<sup>3</sup> concentrate over 1/3 (36%) of Europe's scientific potential. In contrast, there are numerous small and medium-sized poles, since 1/3 of European regions produce less than 0.5% of the scientific publications in Europe. Medium and small-scale scientific poles are linked to academic research centres located throughout European countries.

The economic region of London, which produces 6.4% of Europe's scientific publications, ranks number one among Europe's 15 leading regions. The economic region of Paris, which produces 5.9% of Europe's publications, ranks second, followed by Randstad-Holland (3.5%), Ruhr (2.6%), the bipolar region of Stuttgart-Karlsruhe (2%) and Munich (1.8%).

Chart 3 shows that the scientific performance of major European agglomerations is multidisciplinary. The regions do not appear to have favoured a particular scientific discipline, as is the case in the field of technology. London, Paris, Randstad-Holland and Rhein-Ruhr are the leading economic regions in most scientific disciplines. Although London is ranked first for publications in fundamental biology, applied biology - ecology, medical research and engineering, Paris leads in the four other disciplines. London's leading position in life sciences is all the more significant considering the rapid development of these disciplines.

<sup>&</sup>lt;sup>2</sup> http://www.obs-ost.fr

<sup>&</sup>lt;sup>3</sup> The 15 leading European regions were determined based on a classification of European regions in the administrative division of NUTS 2 and the examination of the regional classification based on GEMACA's division.

	1	2	3	4	5
Fundamental Biology				Rhein-Ruhr*	Stuttgart
Medical Research				Milan	Rhein-Ruhr*
Applied Biology	London	Paris*	Randstad*	Madrid	Munich
Ecology					
Engineering				Rhein-Ruhr*	Stuttgart
Chemistry		London*	Rhein-Ruhr*	Stuttgart	Rhone-Alps
Physics		Rhein-Ruhr*	Stuttgart	Rhone-Alps	London* /
	Paris*				Berlin
Earth / Space Science		Randstad*	London*	Munich	Cambridge
Mathematics		Rhein-Ruhr*	London*	Randstad*	Rhone-Alps
All Disciplines	London*	Paris*	Randstad*	Rhein-Ruhr*	Stuttgart

**Chart 3: The 5 Leading Economic Regions in Europe by Discipline (1998)**<sup>4</sup>

\* Economic regions classified by Gemaca.

Source: ISI data (SCI, COMPUMATH), processed by the OST and the IAURIF, 2001

#### 2.2 Scientific Performance of Functional Urban Regions in Northwest Europe

Functional urban regions in northwest Europe (FURs) with over one million inhabitants represent 17.2 % of the population, 17.6 % of jobs and 28.6 % of Europe's GDP (the 15 member countries in the EU).



Source: ISI data (SCI, COMPUMATH), processed by the OST and the IAURIF, 2001

These regions also produce 26 % of the European Union's scientific publications. The proportion is even higher with regard to medical research (29.7%), fundamental biology (27.2%) and mathematics (26.7%). On the other hand, it is considerably lower in applied biology-ecology (18.2%), chemistry (21.2%) and Earth/Space sciences (21.9%). Scientific performance is in part attributed to 5 economic regions within the FURs that are ranked

<sup>&</sup>lt;sup>4</sup> Classified based on the percentage of scientific publications written within the region. Stuttgart, Munich and Milan respectively represent the regions of Stuttgart - Karlsruhe, Upper Bavaria and Lombardy (NUTS-2 scale).

among the 15 most productive in Europe: London, Paris, Randstad-Holland, Rhein-Ruhr and Brussels.

Between 1990 and 1998, a decrease was observed in the performance of the functional urban regions (FURs) in northwest Europe. The proportion of articles published in the 13 regions fell from 31.4 % in 1990 to 26 % in 1998. The drop is not due to a reduced number of articles published, but to slower growth in the FURs than in the rest of Europe (see following graph). Countries such as Spain and Italy demonstrated high growth rates. Likewise, certain regions in Germany, France and the United Kingdom saw considerable growth such as Bavaria, Saxony, Toulouse, Nice and northern Scotland (OST, 2000).



Source: ISI data (SCI, COMPUMATH), processed by the OST and the IAURIF, 2001

#### 2.3 FURs Performance in Science

The performance of functional metropolitan areas in northwest Europe (FUR) can be further assessed. The results reveal significant differences between the 13 regions examined.

Areas such as London (6.3 % of Europe's scientific publications) and Paris (5.9 %) are the logical leaders both in northwest Europe and the European Union. Scientific research in these two "global cities" is highly diverse, which is why they are consistently among the leading regions in Europe.

Next in line are the functional urban regions of Randstad-Holland (3.5%) and Rhein-Ruhr (2.6%). Scientific research in Randstad ranks particularly high in Earth / Space sciences (second leading European region), life sciences (fundamental biology, medical research and applied biology-ecology), engineering and mathematics (fourth leading European region). Rhein-Ruhr is a leading region for scientific research in mathematics and physics (second

Europe region), chemistry (third European region), fundamental biology and engineering (fourth European region).

Finally, Brussels (1.7% of the EU's publications) and Rhein-Main (1.3%), are positioned ahead of the remaining northwest regions. Some of the 9 regions are highly specialised in certain scientific disciplines.



Source: ISI data (SCI, COMPUMATH), processed by the OST and the IAURIF, 2001

An assessment of the performance of the metropolitan areas in northwest Europe can be made in the eight scientific disciplines studied.



The scientific competitiveness of the FURs in 1998



#### 2.3.1. Fundamental Biology

In 1998, the functional urban regions represented 27.2 % of the European Union, particularly within the three leading regions – London, Paris and Randstad-Holland – which concentrate 17.3 % of Europe's scientific production. Despite good performances, none of the 13 regions has specialised in this discipline, since the specialisation indexes do not exceed 1.09 (Paris).

Between 1990 and 1998, the european share of the Furs fell over 5 percentage points, in particular, the regions of London (-1.4 point), Paris (-1.3 point) and Randstad (-0.8 point).

	Europe	Europe	Specialisation
	1990	1998	index
	(%)	(%)	1998
Brussels	1.9	1.8	1.03
Antwerp	2.3	0.3	1.05
Rhein-Main	1.2	1.2	0.89
Rhein-Ruhr	2.6	2.3	0.85
Paris	7.9	6.6	1.07
Lille (cross border)	0.5	0.5	0.99
Randstad	4.6	3.8	1.04
London	8.3	6.9	1.04
Birmingham	0.9	0.7	0.83
Liverpool-Manchester	0.9	0.8	0.75
Edinburgh	1.0	1.0	1.05
Glasgow	1.1	0.9	1.03
Dublin	0.3	0.3	0.89
TOTAL	31.3	27.2	<u>n.s</u>

**Chart 4: Fundamental Biology in Europe's FURs** 

#### The scientific competitiveness of the FURs in 1998



#### 2.3.2. Medical Research

In 1998, the functional urban regions represented 29.7 % of the EU's scientific publications, despite a fall of over 6 points since 1990. The economic regions of London (9.4 %), Paris (5.5 %) and Randstad-Holland (4.3 %) concentrate 19.2 % of the scientific publications in the European Union, or two-thirds of the FUR's production. Between 1990 and 1998, London (-3.6 points) and, more moderately, Paris (-0.5 point) and Birmingham (-0.5 point) produced less in Europe.

Medical research is an important element in the scientific potential of London and Dublin, with specialisation indexes of 1.29 and 1.21 respectively.

	Europe	Europe	Specialisation
	1990	1998	index
	(%)	(%)	1998 *
Brussels	1.8	1.7	0.87
Antwerp	0.3	0.3	0.92
Rhein-Main	1.1	1.0	0.72
Rhein-Ruhr	2.2	2.2	0.75
Paris	6.0	5.5	0.81
Lille (cross border)	0.4	0.5	0.91
Randstad	4.4	4.3	1.08
London	13.0	9.4	1.29
Birmingham	1.5	1.0	1.02
Liverpool-Manchester	1.5	1.4	1.14
Edinburgh	1.5	1.1	0.99
Glasgow	1.7	1.0	1.06
Dublin	0.6	0.4	1.21
TOTAL	36.0	29.7	n.s

#### **Chart 5: Medical Research in Europe's FURs**

\* Indexes over 1.25 are marked in bold to indicate a high degree of specialisation.

#### The scientific competitiveness of the FURs in 1998



#### 2.3.3. Applied Biology and Ecology

18.2 % of Europe's scientific publications in applied biology and ecology are produced in the functional urban regions studied, and represent the lowest proportion among the scientific disciplines examined. London (4.3 %), Paris (3.4 %) and Randstad Holland (2.6 %) are the leading major agglomerations in this part of Europe. Edinburgh, Antwerp and Glasgow are highly specialised in this scientific field, even though they alone represent the total production of Randstad-Holland.

Between 1990 and 1998, the functional urban regions lost 4 points, falling from 22.5 % to 18.2 % in Europe's scientific production. The drop particularly concerned London, Ruhr and Randstad.

	Europe	Europe	Specialisation
	1990	1998	index
	(%)	(%)	1998 *
Brussels	1.4	1.4	1.22
Antwerp	0.3	0.3	1.92
Rhein-Main	1.0	0.7	0.82
Rhein-Ruhr	2.4	1.7	0.91
Paris	3.8	3.4	0.83
Lille (cross border)	0.1	0.2	0.54
Randstad	3.3	2.6	1.05
London	6.2	4.3	0.97
Birmingham	0.6	0.5	0.79
Liverpool-Manchester	0.5	0.5	0.70
Edinburgh	1.8	1.5	2.26
Glasgow	1.0	0.9	1.51
Dublin	0.3	0.2	1.15
TOTAL	22.5	18.2	n.s

#### **Chart 6: Applied Biology and Ecology in Europe's FURs**

\* Indexes over 1.25 are marked in bold to indicate a high degree of specialisation.

#### The scientific competitiveness of the FURs in 1998



#### 2.3.4. Chemistry

In the field of chemistry, the 13 regions of northwest Europe represent 21.2 % of the European Union's scientific production, which is below the average observed for all disciplines combined (26%). The three top functional metropolitan areas (Paris, London and Rhein-Ruhr), are also ahead of all the regions in the European Union. (see chart 3).

Four functional metropolitan areas – Rhein-Main, Rhein-Ruhr, Birmingham and Lille – have become highly specialised in this field.

	Europe	Europe	Specialisation
	1990	1998	index
	(%)	(%)	1998 *
Brussels	1.3	1.7	1.21
Antwerp	0.2	0.2	1.03
Rhein-Main	2.4	2.0	1.92
Rhein-Ruhr	4.5	3.2	1.51
Paris	5.7	4.9	1.02
Lille (cross border)	0.4	0.5	1.25
Randstad	2.7	2.3	0.79
London	5.1	3.3	0.63
Birmingham	0.9	0.9	1.38
Liverpool-Manchester	1.2	1.1	1.21
Edinburgh	0.6	0.5	0.65
Glasgow	0.6	0.5	0.78
Dublin	0.3	0.2	0.88
TOTAL	26.0	21.2	n.s

#### **Chart 7: Chemistry in Europe's FURs**

\* Indexes over 1.25 are marked in bold to indicate a high degree of specialisation..

#### The scientific competitiveness of the FURs in 1998



#### 2.3.5. Physics

The functional urban regions represent 23.8 % of the European Union's production, which is below the average observed for all disciplines combined (26 %). The economic region of Paris takes the lead, with 7.1 % of the EU's publications, followed by Rhein-Ruhr (3.8 %) and London (3.1 %). Four regions report a high degree of specialisation Rhein-Ruhr, Rhein-Main, Paris and Antwerp.

Between 1990 and 1998, the position of the FURs in the EU dropped nearly 5 points, falling from 28.6 % to 23.8 %, particularly in Paris (-1.9 point), London (-1.1 point) and Randstad (-0.6 point).

	Europe	Europe	Specialisation
	1990	1998	index
	(%)	(%)	1998 *
Brussels	1.6	1.8	1.15
Antwerp	0.3	0.3	1.28
Rhein-Main	2.0	1.9	1.59
Rhein-Ruhr	4.4	3.8	1.60
Paris	9.0	7.1	1.31
Lille (cross border)	0.5	0.5	1.16
Randstad	3.3	2.6	0.82
London	4.2	3.1	0.54
Birmingham	0.7	0.7	0.93
Liverpool-Manchester	1.0	0.8	0.76
Edinburgh	0.6	0.5	0.55
Glasgow	0.6	0.6	0.76
Dublin	0.4	0.2	0.89
TOTAL	28.6	23.8	n.s

#### **Chart 8: Physics in Europe's FURs**

\* Indexes over 1.25 are marked in bold to indicate a high degree of specialisation..

The scientific competitiveness of the FURs in 1998



#### 2.3.6. Earth / Space Sciences

Publications in the 13 functional urban regions in northwest Europe represent 21.9 % of the research conducted in the European Union. Paris (6.3 %), Randstad (3.8 %) and London (3.7 %) come largely ahead of the other regions in this part of Europe. Between 1990 and 1998, the 13 FURs dropped 4.9 points, from 26.8 % to 21.9 %. This drop was particularly notable in London (-1.6 point), Paris (-0.9 point), Ruhr (-0.8 point) and Randstad (-0.6 point).

Universal science is an important part of scientific research in Randstad and Paris.

	Europe	Europe	Specialisation
	1990	1998	index
	(%)	(%)	1998 *
Brussels	1.1	1.4	0.95
Antwerp	0.2	0.1	0.64
Rhein-Main	0.9	1.0	0.91
Rhein-Ruhr	2.8	2.0	0.90
Paris	7.2	6.3	1.26
Lille (cross border)	0.2	0.3	0.73
Randstad	4.4	3.8	1.31
London	5.3	3.7	0.70
Birmingham	0.7	0.6	0.88
Liverpool-Manchester	1.0	0.7	0.77
Edinburgh	1.4	1.1	1.45
Glasgow	1.0	0.7	0.99
Dublin	0.5	0.2	0.83
TOTAL	26.8	21.9	n.s

**Chart 9: Earth / Space Sciences in Europe's FURs** 

\* Indexes over 1.25 are marked in bold to indicate a high degree of specialisation..

#### The scientific competitiveness of the FURs in 1998



#### 2.3.7. Engineering

25.4% of scientific production in science & engineering is carried out in the 13 regions in northwest Europe. London (5.6% of production in Europe), Paris (5.2%), Randstad (3.2%) and Ruhr (3.1%) are among the leading regions. The proportion of production in the 13 functional urban regions in Europe fell 5 points between 1990 and 1998, particularly in London (-1.9 point), Rhein-Ruhr (-1.9 point), Paris (-0.7 point) and Rhein-Main (-0.5 point).

Two English agglomerations (Liverpool-Manchester and Birmingham) are highly specialised in this field.

	Europe	Europe	Specialisation
	1990	1998	index
	(%)	(%)	1998 *
Brussels	1.6	1.9	1.15
Antwerp	0.1	0.1	0.59
Rhein-Main	1.6	1.1	0.90
Rhein-Ruhr	5.0	3.1	1.22
Paris	5.9	5.2	0.89
Lille (cross border)	0.5	0.5	1.04
Randstad	3.4	3.2	0.94
London	7.5	5.6	0.90
Birmingham	1.2	1.1	1.33
Liverpool-Manchester	1.7	1.6	1.52
Edinburgh	0.9	1.0	1.06
Glasgow	0.9	0.8	1.04
Dublin	0.3	0.2	0.73
TOTAL	30.5	25.4	n.s

#### **Chart 10: Engineering in Europe's FURs**

\* Indexes over 1.25 are marked in bold to indicate a high degree of specialisation..

#### The scientific competitiveness of the FURs in 1998



#### 2.3.8. Mathematics

In the field of mathematics, Paris is the clear leader among the 13 functional urban regions and throughout the rest of Europe, with 10.2 % of the production in the European Union. The next most productive regions are Ruhr (3.6 %), London (3.4 %) and Randstad (2.7 %). Lille, Paris and Ruhr are highly specialised in mathematics.

Between 1990 and 1998, scientific production in the 13 regions fell 5 points, dropping from 31.8% to 26.7% in Europe. The decline was particularly noticeable in Paris, Ruhr and Randstad.

	Europe	Europe	Specialisation
	1990	1998	index
	(%)	(%)	1998 *
Brussels	2.1	1.6	0.90
Antwerp	0.3	0.3	1.15
Rhein-Main	1.5	1.0	0.80
Rhein-Ruhr	4.5	3.6	1.35
Paris	11.5	10.2	1.69
Lille (cross border)	0.6	0.9	1.78
Randstad	3.5	2.7	0.77
London	3.8	3.4	0.51
Birmingham	1.0	0.6	0.71
Liverpool-Manchester	0.8	0.8	0.68
Edinburgh	0.9	0.7	0.72
Glasgow	0.8	0.8	0.91
Dublin	0.6	0.2	0.59
TOTAL	31.8	26.7	n.s

#### **Chart 11: Mathematics in Europe's FURs**

\* Indexes over 1.25 are marked in bold to indicate a high degree of specialisation..

## **3. Technological Performance of Functional Urban regions in Northwest Europe**

Technological performance in European regions was evaluated according to the number of European patents calculated by the french Observatory of Science and Techniques (OST),<sup>5</sup> based on data collected by the Observatory of European Patents (OEB, see annex).

#### 3.1 Major Innovative Regions in Europe

The measure of innovation among the regions based on registered patents confirms the geographic differences previously observed (see map 2). Technological performance is highly concentrated; among some 211 regional geographic divisions defined by Eurostat (NUTS-2 scale), 75 % of them produce less than 0.5 % of European patents. Fifteen European regions concentrate nearly 45 % of the patents in Europe. Eight of the regions are German, thus underlining the technological strength of Germany in Europe. By comparison, France and the Netherlands only have 2 such regions. It should be noted that the 15 regions in question are all located north of an area extending from northern Italy (Lombardy) to the Rhone-Alps region.

In terms of gross results, the functional metropolitan area of Paris had 6.2 % of the registered patents in Europe in 1998, making it the leading European region in technological performance. It is only slightly ahead of the bipolar region of Stuttgart-Karlsruhe and the Rhein-Ruhr region, each of which concentrate 6.1 % of Europe's patents. The following two regions – Munich and Rhein-Main – are also German, each of which produces approximately 4 % of Europe's patents.

Of course, the European regions do not all have the same type of technological activities. By applying the previous classification of European regions to the fields of technology, one will note that certain European regions stand out among the rest, notably Rhein-Ruhr, Paris, Stuttgart and Munich.

	Chemistry	Electronics	Instrumen-	Machines -	Household -	Industrial
	Pharmaceuticals	- Electricity	tation	Mechanics	civil eng.	Processes
1	Rhein-Ruhr*	Pa	aris*	Stuttgart	Rhein	-Ruhr*
2	Paris*	Munich	Stuttgart	Rhein-Ruhr*	Stut	tgart
3	Rhein-Main*	Noord-	Munich	Paris*	Par	is *
		Brabant				
4	London*	Stuttgart	London*	Rhein-Main*	Rhone-Alps	Rhein-Main*
5	Milan	Stockholm	Rhein-Ruhr*	Munich	Mu	nich

**Chart 12: The 5 Leading European Regions by Technological Field (1998)**<sup>6</sup>

\* Functional urban region based on the Gemaca method; Stuttgart designates the Stuttgart - Karlsruhe region

<sup>&</sup>lt;sup>5</sup> http://www.obs-ost.fr

<sup>&</sup>lt;sup>6</sup> Classification based on the percentage of European patents registered in the region.

Source: INPI and OEB data, statistics gathered by the OST and the IAURIF, 2001



Source : data INPI / EPO processed by OST and IAURIF, 2001

Echelle : 0 500Km

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#### 3.2 Technological Performance in Northwest Europe

The functional urban regions in northwest Europe (FURs) with more than one million inhabitants represent 17.2 % of the population, 17.6 % of jobs and 28.6 % of Europe's GDP (the 15 member countries in the EU). These regions also produce 23.4 % of the registered patents within the European Union. This proportion is even more significant in "fine chemistry – pharmaceuticals" (34.4 %) and "Techniques – basic chemistry –metallurgy" (26.3 %). In contrast, it is much lower in the fields of electricity-electronics (19.2%), "household consumption – civil engineering" (19.7 %) and "machinery-mechanics – transport" (21.9 %).



Source: INPI and OEB data, statistics gathered by the OST and the IAURIF, 2001

Between 1990 and 1998, performance within the 13 economic regions in northwest Europe declined. In fact, registered European patents among the FURs dropped from 24.8 % to 23.4 %, or a 1.4-point decrease. This is attributed to a lower growth of European patents registered in the Furs than in the rest of the European Union (see chart 13).

## Chart 13: Growth of European Patents Registered Between 1990 and 1998 (in %)

	Electronics- Electricity	Instrumenta- tion	Fine Chemistry- Pharma- ceutics	Techniques- Basic Chemistry- Metallurgy	Machinery- Mechanics- Transportation	Household Consumption- civil engineering	All
FURs	65.7%	63.0%	61.0%	37.7%	48.0%	55.5%	53.6%
European Union	91.8%	67.1%	65.2%	48.6%	52.6%	60.0%	62,7%

Source: INPI and OEB data, statistics gathered by the OST and the IAURIF, 2001

#### 3.3 Technological Strengths and Weaknesses of the FURs

Paris and Rhein-Ruhr are the leading regions in technological performance in Europe, with over 6 % of the registered European patents. The economic region of Paris remains among the three leading European regions in technological performance, and rates number one in the fields of electricity-electronics and instrumentation. Rhein-Ruhr is the leading European region in chemistry-pharmaceuticals, household consumption-BTP and industrial processes.



The economic regions of Rhein-Main, London, Randstad and Brussels, which reflect considerable differences, follow these regions. Rhein-Main (3.7 % of registered patents) shows strong performance in chemistry-pharmaceuticals, machines-mechanics and industrial processes. The economic region of London represents 2.9 % of Europe's registered patents, with notable results in fine chemistry-pharmaceutics and instrumentation.



Source: INPI and OEB data, statistics gathered by the OST and the IAURIF, 2001

An assessment can be made regarding the performance of Europe's northwestern Furs in each of the six fields studied. The specialisation index has been used to identify the strengths and weaknesses of the 13 regions examined. This index sheds light on the advantages and disadvantages in the regions in northwest Europe.

#### The technological competitiveness of the FURs in 1998



#### 3.3.1. Electronics - Electricity

The functional urban regions in northwest Europe represent 19.2 % of the registered European patents in the European Union. The economic region of Paris is the leading region (7.9 %), followed by Rhein-Ruhr (3 %), London (3 %), Rhein-Main (2.2 %) and Randstad (1.2 %). Paris, London and Glasgow are highly specialised in this technological field.

Between 1990 and 1998, technological performance in the FURs fell from 22.3 % to 19.2 %. The economic region of Paris dropped sharply (-4.7 points), as did London (-0.4 point) and Ruhr (-0.3 point). However, performance in the regions of Randstad (+0.6 point), Rhein-Main (+0.5 point) and Brussels (+0.4 point) increased.

	Europe	Europe	Specialisation
	1990	1998	index
	(%)	(%)	1998 *
Brussels	0.3	0.7	0.94
Antwerp	0.2	0.3	0.81
Rhein-Main	1.7	2.2	0.72
Rhein-Ruhr	2.7	3.0	0.60
Paris	12.6	7.9	1.55
Lille (cross border)	0.1	0.1	0.48
Randstad	0.6	1.2	0.78
London	3.4	3.0	1.28
Birmingham	0.2	0.2	0.59
Liverpool-Manchester	0.2	0.3	1.06
Edinburgh	0.1	0.1	1.19
Glasgow	0.1	0.2	1.25
Dublin	0.0	0.0	1.11
TOTAL	22.3	19.2	n.s

#### **Chart 14: Electronics-Electricity in Europe's FURs**

\* Indexes over 1.25 are marked in bold to indicate a high degree of specialisation..



#### The technological competitiveness of the FURs in 1998

#### 3.3.2. Instrumentation

In 1998, the FURs produced 22 % of Europe's registered patents in instrumentation. The region of Paris (6.6 %) ranks number one among the 13 regions studied, followed by London (3.8 %), Rhein-Main (3.4 %), Rhein-Ruhr (3.4 %) and Randstad (1.6 %). Antwerp, Dublin and nearly all of the British regions studied have highly specialised technology in this field.

Between 1990 and 1998, the FURs technological performance within the European Union has fallen slightly, from 22.5 % to 22 %. This is particularly manifested in Paris (-2.3 points) and, to a lesser degree, in London (-0.6 point). By comparison, performance in the regions of Antwerp (+0.5 point), Brussels (+0.4 point) and Randstad (+0.4 point) increased.

	Europe	Europe	Specialisation
	1990	1998	index
	(%)	(%)	1998 *
Brussels	0.3	0.7	0.75
Antwerp	0.4	0.9	2.49
Rhein-Main	3.6	3.4	1.00
Rhein-Ruhr	3.7	3.4	0.60
Paris	8.9	6.6	1.13
Lille (cross border)	0.3	0.3	0.96
Randstad	1.2	1.6	0.90
London	3.2	3.8	1.41
Birmingham	0.2	0.2	0.59
Liverpool-Manchester	0.4	0.5	1.52
Edinburgh	0.1	0.2	1.87
Glasgow	0.2	0.3	1.72
Dublin	0.1	0.0	1.52
TOTAL	22.5	22.0	n.s

#### **Chart 15: Instrumentation in Europe's FURs**

\* Indexes over 1.25 are marked in bold to indicate a high degree of specialisation..

#### The technological competitiveness of the FURs in 1998



#### 3.3.3. Fine Chemistry - Pharmaceutics

The functional urban regions in northwest Europe are highly active in fine chemistry and pharmaceutics, as they represented 34.4 % of registered European patents in 1998. Leading regions include Rhein-Ruhr (9.1 % of registered patents), Paris (7.6 %), Rhein-Main (5.7 %), London (5.4 %), Randstad (2.8 %) and Brussels (1.8 %).

Between 1990 and 1998, performance among the 13 regions fell slightly, from 35.3 % to 34.4 %. There was a particularly sharp drop in Rhein-Ruhr (-4.6 points), London (-2 points) and Randstad (-0.5 point). Performance increased, however, in Paris (+1.2 point) and Brussels (0.5 point).

	Europe	Europe	Specialisation
	1990	1998	index
	(%)	(%)	1998 *
Brussels	1.3	1.8	1.32
Antwerp	0.1	0.4	0.63
Rhein-Main	6.0	5.7	1.06
Rhein-Ruhr	13.7	9.1	1.02
Paris	6.4	7.6	0.84
Lille (cross border)	0.2	0.3	0.64
Randstad	3.3	2.8	1.04
London	3.4	5.4	1.29
Birmingham	0.1	0.2	0.37
Liverpool-Manchester	0.3	0.4	0.75
Edinburgh	0.1	0.3	1.29
Glasgow	0.2	0.3	0.99
Dublin	0.1	0.0	0.54
TOTAL	35.3	34.4	n.s

#### **Chart 16: Fine Chemistry – Pharmaceutics in Europe's FURs**

\* Indexes over 1.25 are marked in bold to indicate a high degree of specialisation..



#### 3.3.4. Techniques - Basic Chemistry - Metallurgy

The 13 regions in northwest Europe represent 26.3 % of registered European patents in this field of technology. Rhein-Ruhr (9.9 % of registered European patents), Paris (4.9 %), Rhein-Main (4.2 %), Randstad (2.1 %) and London (1.7 %) are the leading regions. Moreover, the regions of Brussels, Rhein-Ruhr and Lille are specialised in this field.

Performance in the 13 regions dropped 2 points between 1990 and 1998, falling from 28.3 % to 26.3 %. Decreases were particularly observed in Rhein-Ruhr (-2.3 points), Paris (-0.7 point) and Rhein-Main (-0.4 point). However, the regions of Brussels (+0.8 point) and London (+0.3 point) demonstrated greater performance.

	Europe	Europe	Specialisation
	1990	1998	index
	(%)	(%)	1998 *
Brussels	0.7	1.5	1.40
Antwerp	0.2	0.3	0.79
Rhein-Main	4.6	4.2	1.03
Rhein-Ruhr	12.2	9.9	1.45
Paris	5.6	4.9	0.70
Lille (cross border)	0.4	0.5	1.33
Randstad	2.4	2.1	1.00
London	1.4	1.7	0.54
Birmingham	0.2	0.4	0.95
Liverpool-Manchester	0.4	0.4	1.15
Edinburgh	0.0	0.1	0.42
Glasgow	0.1	0.2	0.74
Dublin	0.0	0.0	0.78
TOTAL	28.3	26.3	n.s

#### Chart 17: Techniques, Basic Chemistry and Metallurgy in Europe's FURs

\* Indexes over 1.25 are marked in bold to indicate a high degree of specialisation..

The technological competitiveness of the FURs in 1998



#### 3.3.5. Machinery - Mechanics - Transport

Rhein-Ruhr and Paris each represents 5.4 % of registered European patents in the EU in this field of technology. Other leading regions include Rhein-Main (3.8 %), London (1.7 %) and Randstad (1.6 %). Together, the FURs concentrate 20.1 % of Europe's registered patents, a clearly lower proportion than that observed in other fields of technology.

Between 1990 and 1998, performances among the 13 functional urban regions in the EU fell only slightly, from 20.8 % to 20.1 %. Developments among the 13 economic regions varied; while performance in Paris (-2.7 points) and Rhein-Ruhr (-0.8 point) dropped, Rhein-Main (+1.5 point) and London (+0.5 point) demonstrated an increase.

	Europe	Europe	Specialisation
	1990	1998	index
	(%)	(%)	1998 *
Brussels	0.2	0.5	0.60
Antwerp	0.2	0.3	0.96
Rhein-Main	2.3	3.8	1.20
Rhein-Ruhr	6.2	5.4	1.03
Paris	8.1	5.4	1.01
Lille (cross border)	0.3	0.4	1.30
Randstad	1.3	1.6	1.02
London	1.2	1.7	0.69
Birmingham	0.6	0.6	2.01
Liverpool-Manchester	0.2	0.2	0.71
Edinburgh	0.0	0.1	0.67
Glasgow	0.1	0.1	0.65
Dublin	0.1	0.0	0.96
TOTAL	20.8	20.1	n.s

#### Chart 18: Machines, Mechanics and Transport in Europe's FURs

\* Indexes over 1.25 are marked in bold to indicate a high degree of specialisation..



The technological competitiveness of the FURs in 1998

#### 3.3.6. Household Consumption – Civil Engineering

In 1998, the functional urban regions in northwest Europe represented only 19.7 % of registered European patents in the EU, the lowest proportion observed of the six fields of technology studied. Rhein-Ruhr is the leading European region, with 5.8 % of registered patents, followed by Paris (4.6 %), Rhein-Main (2.5 %), London (2.3 %) and Randstad (2.1 %). Randstad and Dublin are specialised in this field.

Between 1990 and 1998, performance among the FURs within the European Union fell 0.5 point, going down from 20.2 % to 19.7 %. The drop is primarily attributed to Paris, which lost 2.5 points during this period. In contrast, London (+0.7%), Rhein-Main (+0.4 point) and a few other regions reflected an increase in Europe.

	Europe	Europe	Specialisation
	1990	1998	index
	(%)	(%)	1998 *
Brussels	0.4	0.6	0.75
Antwerp	0.3	0.2	0.73
Rhein-Main	2.1	2.5	0.80
Rhein-Ruhr	5.7	5.8	1.14
Paris	7.1	4.6	0.89
Lille (cross border)	0.4	0.4	1.43
Randstad	1.8	2.1	1.37
London	1.6	2.3	0.93
Birmingham	0.3	0.5	1.63
Liverpool-Manchester	0.2	0.3	1.19
Edinburgh	0.1	0.1	0.72
Glasgow	0.2	0.2	0.98
Dublin	0.1	0.1	1.84
TOTAL	20.2	19.7	n.s

 Tableau 19: Household Consumption and civil engineering in Europe's FURs

\* Indexes over 1.25 are marked in bold to indicate a high degree of specialisation..

### Conclusion

The scientific and technological performance of the functional urban regions studied is quite remarkable, since the 13 regions represent respectively 26 % and 23 % of the scientific and technological production in Europe.

Nonetheless, the regions presented varying degrees of performance in 1998. Six regions in particularl largely prevail over the 13 overall regions examined. The economic region of Paris leads in both scientific and technological performance, followed by London and Rhein-Ruhr. While London demonstrates the best scientific performance in Europe, it ranks lower in technology. In contrast, the technological performance of the Rhein-Ruhr region is comparable to that of Paris, while its scientific production is more modest. Randstad-Holland and Rhein-Main are next in line, with Randstad ahead of Rhein-Main in scientific performance, but behind the latter in the field of technology.



Source: INPI and OEB data, statistics gathered by the OST and the IAURIF, 2001

Between 1990 and 1998, the functional urban regions in northwest Europe underwent a relative drop in performance. The proportion of articles published in the 13 regions fell from 31.4 % in 1990 to 26 % in 1998. Likewise, the percentage of registered European patents

decreased from 24.8 % in 1990 to 23.4 % in 1998. In both cases, the decline is attributed to a slowdown in the number of articles published and registered patents among the FURs compared to the rest of Europe. This reflects a wider spread of science throughout a number of major European poles, and increased performance in southern Europe, Finland, Ireland and certain Länders in former East Germany. In the field of technology, significant developments are observed in the Nordic countries, to the detriment of the strongest regions with the exception of Stuttgart and, more recently, Munich.

#### Chart 20: Scientific and Technological Performance in Europe's Functional Urban Regions between 1990 and 1998

	Europe 1990	Europe 1998	Growth (in %)
Scientific			
Publications	31.4 %	26.0 %	-5.4 %
European			
Patents	24.8 %	23.4 %	-1.4 %

Source : ISI (publications) and INPI-OEB (european patents) data, processed by the OST and the IAURIF, 2001

### Annexes

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#### Statistical Indicators Used

Although much information on countries' research and innovative capacity has been gathered by international (Eurostat, OECD, NATO, etc.) and state-run (Ministry of Research, OST – Observatory of Science and Techniques in France, for example) organizations, very few statistical indicators are available on a regional scale. The regional analyses in the study were based on two approaches: the "inputs" and "outputs" of different regions.

The approach based on the resources available for research projects (input) involved taking an inventory of the financial resources associated with spending on research and development (individual R&D budget, DIRD on a regional or national level). Calculations were also made of the human resources employed in R&D. An important international indicator is the number of researchers, expressed in "equivalent full time" (ETP), as well as research assistants, which comprise the overall R&D personnel. However, it is difficult to make a precise international comparison in this field due to varying degree equivalences and cultural differences; for example, research assistants are quite recent in Japan, where researchers conduct the majority of the work, and they are not accounted for in the United States.

The approach based on results (output) is grounded on two indicators:

- Scientific production is based on the OST's statistics on publications. The OST's publications analysis, which is based on two U.S. databases from the *Institute of Scientific Information*, covers all the sciences with the exception of social science.
- Technological performance was evaluated according to the number of patents registered. In Europe, the study was based on statistics on European patents published by the OST, according to data gathered by the INPI and the OEB. In Japan, the study was based on the NISTEP's statistics on Japanese patents.

#### Definition of Functional Urban Regions (FURs)

For the European Union, the administrative division of regions poses a problem in the direct comparison of their scientific and technological performances; often administrative regions are not very greatly in relation to economic regions. In Germany, for example, the agglomerations of Düsseldorf and Köln actually form one economic region – Rhein-Ruhr. Likewise, the economic region of London extends largely beyond *Greater London* and doesn't identify with the *South-East* region.

The study is based on the recent work carried out by the European group GEMACA<sup>7</sup>, which geographically defined 14 functional urban regions in northwest Europe according to common criteria such as job density and commuting rate between the home and the work place. The outer perimeter of these economic regions corresponds to the labour force basin. In the assessment of science and technology, the regions of Liverpool and Manchester were considered as a single functional urban region.



Source: Gemaca – Iaurif, 2000

<sup>&</sup>lt;sup>7</sup> http://www.iaurif.org/actions/gemaca/gemaca.htm

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