

## **EDUCATION, RESEARCH AND MANUFACTURING IN EU25: AN INTER-SECTORAL ECONOMETRIC MODEL OF 151 EUROPEAN REGIONS, 1995-2000**

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### ***Abstract***

This article analyses the important differences that exist among regions of the 25 European Union countries, after the enlargement of year 2004, by means of an econometric analysis with a cross-section sample of 151 regions. The main conclusions suggest the convenience of fostering human capital and industrial development, particularly in less favoured regions in order to achieve a higher level of employment and income per inhabitant in those regions. From this point of view EU regional policy should be more flexible and contribute to foster communication among European researchers related with economic development and European institutions.

JEL classification: C5, C51, O18, O52, R23

Keywords: Education, Research, Regional Development, European Regions, Regional Econometric Models, Western and Central Europe

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### **1. Introduction**

European economic policy has had some positive impacts to build infrastructures and foster convergence of income per inhabitant among EU regions, but some criticisms have arisen due to several shortcomings and limitations related with an excess of bureaucratic rigidity and a lack of communication of EU institutions with economic researchers and other social agents who could have a positive role to advice European employment and development policies, particularly in the cases of the less favoured regions. As it is well known European Union has evolved during the last decades below the USA in research and development expenditure, rates of employment and level of real wages. Many citizens and social agents

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of European countries are in favour of improving EU policies in this regard, and the conclusions of this paper agree with this perspective.

Section 2 presents a summary of the main differences existing among the 151 EU regions of 25 countries, regarding education, research expenditure, industry and other variables. Section 3 presents the results of an econometric analysis which has into account the role of industry and human capital to improve regional development in EU, and finally section 4 presents the main conclusions.

## **2. Education, RD, industry and development in EU25 regions.**

Table 1 presents a comparison of Gdp per inhabitant, Gdph, Percentage of population with secondary studies of second cycle complete or more, PS2, and Expenditure in Reserarch and Development per inhabitant, RD, between EU15 and the USA in 1995. Regarding data in table 1 we observe that several EU countries, particularly Spain, Portugal and Greece has very low levels of expenditure in Research and Development per inhabitant. These countries have also the lowest percentages of secondary and superior education, according to their low values of PS2. The differences between European Union and the USA are important because the lower support that many EU countries give to expenditure on RD and Education have as consequence a lower level of real income per inhabitant.

Table 2 presents some of the most important differences among EU25 regions, with data of the following variables: 1) qh00pp: Gdp per inhabitant in year 2000, in current dollars and Purchasing Power Parities, PPPs, calculated applying the regional percentage on EU15 from Eurostat to the average of EU15 in OECD statistics. 2) ps2: percentage of population with secondary studies second cycle or more (average of the sum of percentages of “medium” and “superior” for years 1999 and 2001. 3) eduh: expenditure on public education per inhabitant in year 1995 in dollars at current prices and PPPs. 4) rdh: expenditure on research and development per inhabitant in 1999 in euros, elaborated from Eurostat statistics and our own provisional estimations for 49 regions without available data. 5) path: number of

patents per one million inhabitants in 2000. 6) onsh: Millions of overnight stays per one million inhabitants in 2000.

Tabla 1. Gdp per head, Education and RD Expenditure per head

	gdp95h	PS2	RD Expenditure 1990-94				
Country			Tot.	Bus.	Gov.	HE-ssh	HE-nse
Austria	21853	70	1383	806	102	100	375
Belgium	20532	54	1983	1339	122	157	365
Denmark	27252	62	2398	1382	444	149	423
Finland	25677	66	2420	1448	474	174	324
France	21678	69	2470	1531	544	106	289
Germany	21814	84	3173	2317	426	95	335
Greece	8583	35	253	61	104	24	64
Ireland	16824	47	716	423	128	35 <sup>1</sup>	130 <sup>1</sup>
Italy	20193	35	1388	803	294	64	227
Luxembourg	32897	25	1983	1339	122	157	365
Netherlands	20363	61	2033	1168	377	147	341
Portugal	7297	20	184	55	52	18	59
Spain	13489	28	519	296	117	34	72
Sweden	26647	74	3711	2476	147	163	924
UK	17754	75	2599	1823	354	63	359
EU15	19381	60	2062	1362	331	83	285
USA	23377	71	2987	2186	326	142*	333*

Source. Own elaboration from OECD statistics. Gdp per inhabitant (USD at 1995 prices and exchange rates); Percentage of Population with educational level equal or superior to complete Secondary 2nd level, (PS2) correspond to year 1995, and RD Expenditure for 1990-94. Higher Education includes public and private universities: ssh (social sciences and humanities) and nse (natural sciences and engineering). \* provisional estimation. These data undervalue in some degree Irish data in comparison with Spain, because other indirect expenditures on Higher Education, which benefit RD activities, are much higher in Ireland. The same happens with the USA in comparison with EU15, because indirect support to RD in USA is higher.

Table 2. Gdp per head, Educational level, Public Expenditure on Education, RD expenditure, Patents and Tourism in year 2000

No	Region	qh00pp	ps2	eduh	rdh	path	onsh
1	Bruxelles	52.86	61.3	1063	607	155	4.49
2	Vlaams	25.77	62.5	1063	452	160	1.26
3	Wallone	18.99	58.1	1063	355	117	0.72
4	Denmark	28.81	81.8	1591	641	159	1.72
5	Baden-Württemberg	29.63	79.5	1254	1050	496	2.34
6	Bayern	30.12	80.8	1254	792	440	4.06
7	Berlin	23.22	83.2	1254	813	168	3.17
8	Brandenburg	16.85	93.0	836	259	62	1.87
9	Bremen	34.71	77.8	1254	675	80	1.89
10	Hamburg	44.09	80.7	1254	737	196	2.70
11	Hessen	31.43	81.7	1254	741	343	2.70
12	Mecklenburg-V.	16.85	91.0	836	162	30	4.92
13	Nieder Sachsen	23.32	83.0	1254	502	195	2.10
14	Nordrhein-Westfalia	26.38	79.3	1254	433	261	1.26
15	Rheinland-Pfalz	23.49	80.4	1254	484	294	2.83
16	Saarland	23.51	81.1	1254	211	147	0.87
17	Sachsen	17.10	94.7	836	388	91	2.19
18	Sachsen Anhalt	16.61	91.8	836	195	42	1.26
19	Schleswig-Holstein	23.37	83.8	1254	243	130	2.45
20	Thüringen	16.90	93.4	836	255	70	2.29
21	Voreia	15.59	47.6	361	52	5	2.57
22	Kentriki	14.35	41.2	361	48	1	4.75
23	Attiki	18.73	65.5	361	121	14	2.31
24	Nisia A.-Kriti	16.93	41.6	361	70	3	31.17
25	Galicia	15.71	34.8	654	61	7	2.15
26	Asturias	17.22	39.8	654	70	10	2.31
27	Cantabria	19.50	42.5	654	80	9	4.23
28	Pais Vasco	24.65	51.5	654	200	34	1.31
29	Navarra	25.58	47.9	654	170	48	2.13
30	Rioja	22.15	40.0	654	77	9	2.84
31	Aragon	21.35	42.4	654	114	28	3.18
32	Madrid	26.72	51.8	654	310	37	2.36
33	Castilla y León	18.43	42.5	654	81	10	2.51

34	Castilla-La Mancha	16.22	30.1	654	38	7	1.77
35	Extremadura	12.87	29.2	654	36	3	1.70
36	Cataluña	24.17	43.0	654	184	51	5.95
37	C.Valenciana	19.24	35.5	654	83	25	5.04
38	Baleares	23.88	36.4	654	42	14	67.80
39	Andalucia	14.86	33.8	654	66	6	4.87
40	Murcia	16.68	37.1	654	76	11	2.19
41	Canarias	18.82	35.8	654	63	7	22.35
42	Ille de France	38.45	68.0	1157	1221	290	5.63
43	Champagne-Ardenne	22.98	55.3	1157	105	67	1.73
44	Picardie	19.99	55.2	1157	200	90	1.25
45	Haute Normandie	23.12	58.5	1157	332	104	1.43
46	Centre	22.05	61.8	1157	99	99	2.43
47	Basse Normandie	20.72	60.7	1157	224	54	2.79
48	Bourgogne	22.52	63.3	1157	298	92	2.53
49	Nord-Pas-de-Calais	19.58	56.2	1157	120	42	1.45
50	Lorraine	20.28	63.8	1157	189	79	1.51
51	Alsace	24.99	68.0	1157	293	173	3.41
52	Franche-Comté	21.28	61.2	1157	434	117	1.89
53	Pays de Loire	21.86	66.0	1157	202	58	1.56
54	Bretagne	20.94	70.8	1157	291	72	2.18
55	Poitou-Charentes	20.13	64.5	1157	137	52	3.01
56	Aquitaine	21.96	67.3	1157	291	50	2.75
57	Midi-Pyrennees	21.49	71.3	1157	729	97	3.76
58	Limousin	19.92	66.8	1157	125	43	1.85
59	Rhône-Alps	25.04	68.2	1157	523	223	3.19
60	Auvergne	21.01	65.7	1157	396	90	2.71
61	Languedoc-Rousillon	18.87	59.9	1157	362	58	3.07
62	Provence-Alps-C.Azur	22.05	61.8	1157	348	96	5.09
63	Corse	18.46	42.2	1157	72	7	10.44
64	Ireland	27.98	56.2	1019	286	71	6.38
65	Piemonte	29.05	45.9	1055	365	110	1.30
66	Valle d'Aosta	29.90	43.5	1055	89	18	20.11
67	Liguria	26.26	50.2	1055	239	57	7.25
68	Lombardia	32.67	48.2	1055	293	147	1.97

69	Trentino-Alt Adige	33.11	50.0	1055	121	53	30.96
70	Veneto	28.90	45.0	1055	114	98	5.82
71	Friuli-Venezia Giulia	27.71	49.6	1055	242	109	3.11
72	Emilia-Romagna	31.36	49.9	1055	225	147	7.51
73	Toscana	27.57	45.0	1055	203	59	6.24
74	Umbria	24.43	54.8	1055	171	35	4.13
75	Marche	24.80	46.7	1055	90	56	4.07
76	Lazio	27.42	54.7	1055	422	44	5.03
77	Abruzzo	20.33	48.7	1055	125	60	3.52
78	Molise	19.14	46.0	1055	43	9	1.29
79	Campania	15.86	42.0	1055	123	10	2.57
80	Puglia	16.30	38.9	1055	66	9	1.17
81	Basilicata	17.83	42.6	1055	75	13	1.74
82	Calabria	15.08	44.7	1055	32	7	2.24
83	Sicilia	15.88	40.3	1055	88	14	2.29
84	Sardegna	18.34	38.6	1055	99	10	3.90
85	Luxembourg	47.44	62.4	1254	426	172	2.80
86	Noord Nederland	24.68	65.4	1141	259	73	1.48
87	Oost Nederland	22.90	65.9	1141	399	133	1.16
88	West Nederland	29.97	69.2	1141	515	135	2.52
89	Zuid Nederland	25.75	65.2	1141	579	450	1.31
90	Ost Osterreich	29.90	78.4	1213	310	124	3.65
91	Sud Osterreich	23.29	80.8	1213	304	131	7.07
92	West Osterreich	27.93	76.2	1213	345	177	15.99
93	Norte	13.6	16.6	642	47	3	0.82
94	Centro	13.16	20.0	642	47	3	1.12
95	Lisboa e Val Tejo	22.08	28.9	642	82	6	2.28
96	Alentejo	13.24	20.5	642	37	1	1.60
97	Algarve	16.03	18.3	642	44	3	38.24
98	Açores	12.55	14.5	642	200	1	2.43
99	Madeira	18.07	16.3	642	39	3	20.25
100	Finland	25.26	75.8	1238	615	291	2.57
101	Sweden	25.89	80.8	1511	972	321	2.39
102	North East	18.80	77.9	955	163	75	1.74
103	North West	21.18	80.4	955	392	88	3.08

104	Yorkshire Humberside	21.40	79.0	955	186	75	1.97
105	East Midlands	22.81	79.8	955	387	104	1.39
106	West Midlands	22.35	77.5	955	303	87	1.86
107	Eastern	25.24	83.0	955	851	216	1.02
108	London	35.71	84.3	955	371	92	5.64
109	South East	26.86	87.2	955	747	179	2.43
110	South West	22.10	86.2	955	398	123	5.80
111	Wales	19.58	77.3	955	195	64	3.09
112	Scotland	23.61	80.2	955	298	77	4.92
113	Northern Ireland	18.90	70.8	955	157	29	1.57
114	Cyprus	18.39	66.7	605	31	10	25.05
115	Praha	29.39	94.3	459	115	11	6.00
116	Stredni Cechy	11.41	83.2	459	53	11	1.15
117	Jihozapad	12.73	88.8	459	56	11	1.55
118	Severozapad	11.12	82.7	459	44	11	2.91
119	Severovychod	11.68	87.8	459	53	11	2.53
120	Jihovychod	11.87	88.8	459	64	11	0.96
121	Stredni Morava	10.93	87.7	459	59	11	1.42
122	Moravskoslezsko	11.32	49.0	459	56	11	1.14
123	Estonia	9.74	88.1	213	26	6	1.39
124	Kozep-Magyarország	18.36	81.2	423	41	14	1.84
125	Kozep-Dunantul	12.12	76.3	423	26	14	1.017
126	Nyugat-Dunantul	13.75	76.6	423	28	14	2.700
127	DeI-Dunantul	9.03	71.8	423	28	14	1.754
128	Eszak-Magyarország	7.79	71.1	423	25	14	0.737
129	Eszak-Alfold	7.65	69.0	423	25	14	0.770
130	DeI-Alfold	8.67	71.0	423	25	14	0.485
131	Lithuania	8.67	86.8	143	15	1	0.275
132	Latvia	7.50	83.8	346	10	4	0.621
133	Malta	13.38	38.0	532	33	0	17.99
134	Dolnoslaskie	9.76	83.2	296	29	2	0.50
135	Kujawsko-Pomorskie	8.45	79.5	296	22	2	0.22
136	Lubelskie	6.46	79.3	296	31	2	0.15
137	Lubuskie	8.47	85.1	296	26	2	0.36
138	Lodzkie	8.38	78.5	296	28	2	0.20

139	Malopolskie	8.43	84.2	296	32	2	0.70
140	Mazowieckie	14.30	83.1	296	35	2	0.42
141	Opolskie	8.06	81.5	296	24	2	0.13
142	Podkarpackie	6.70	83.7	296	25	2	0.15
143	Podlaskie	7.02	76.3	296	30	2	0.19
144	Pomorskie	9.49	82.9	296	29	2	0.49
145	Slaskie	10.39	85.8	296	22	2	0.17
146	Swietokrzyskie	7.38	79.0	296	23	2	0.20
147	Warminsko-Mazurskie	7.04	76.2	296	23	2	0.64
148	Wielkopolskie	10.05	83.8	296	24	2	0.29
149	Zachodniopomorskie	9.30	79.5	296	30	2	0.42
150	Slovenia	16.32	76.6	443	143	21	2.30
151	Slovakia	11.15	86.5	380	23	5	1.03

Sources: Eurostat, OECD and own estimation for unavailable data.

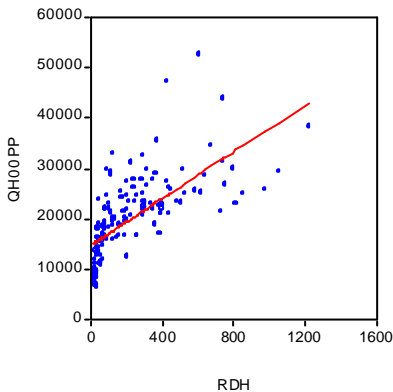
Notes: Gdphpp is Gdp per inhabitant in year 2000, at current dollars and PPPs. Ps2 is the percentage of population from 25 to 59 years with secondary studies of second cycle or superior. Eduh is expenditure per inhabitant on public education in years 95, at current dollars and PPPs. Rdh is expenditure on Research and Development per inhabitant in year 1999 at current prices in Euros. Path and Onsh are, respectively, one million of patents and one million of overnight stages at hotels per one million inhabitants, in year 2000. All data are at regional level but Eduh has been calculated at national level.

There are outstanding differences, among EU regions, not only in real Gdp per inhabitant but also in educational level and expenditure per inhabitant in Research and Education. These EU disparities are higher than in the USA, where there is a higher degree of real convergence in regional income per inhabitant, education and RD. In the next section we present an econometric model which shows the important impact of these variables on regional development, having into account also the important impact of industrial Value-Added.

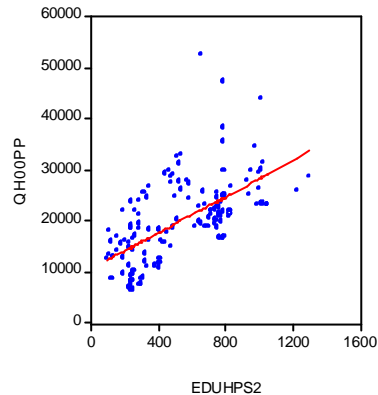
Graphs 1 to 4 show the positive relationships of Gdph with Research, Education, Industry and Tourism. Regarding Education we have had into account the variable  $Eduhps2 = Eduh * ps2 / 100$ , which increase both with the percentage of population with secondary or higher studies and with the average public expenditure on education.



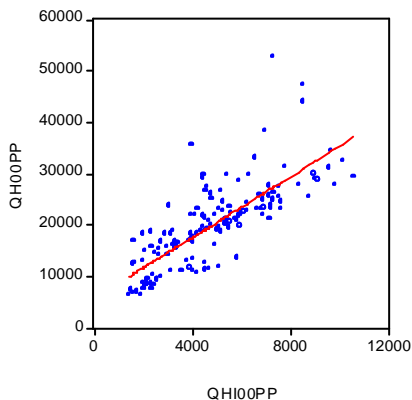
Graph1. Gdph and RD Expenditure



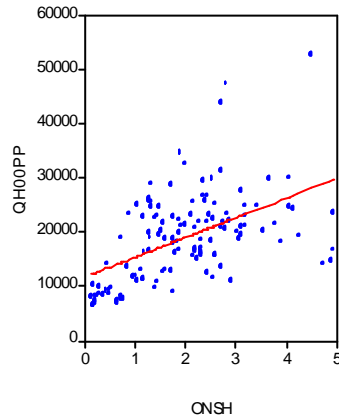
Graph 2. Gdph and Education



Graph 3. Gdph and Industry



Graph4. Gdph and Tourism



Regarding RD we have found that RD Expenditure is more positively related with Gdp per inhabitant than Patents. This is partly due to two circumstances: 1) Patents may be used very far from where they were developed, not necessarily in the same region. 2) There are many research activities in Social Sciences and Humanities, and other subjects, which do not produce patents but which have an important positive impact on regional development.

### 3.- Econometric models of 151 European Regions

We present the estimation by LS and TSLS of a system of two equations which relation QIH and QNIH, real Value-Added per inhabitant in Industrial and Non-Industrial sectors. Among the explanatory values there are: Educational Level, measured by PS2, Tourism, represented by Onsh, and RD activities represented by the number of patents. We have included also some dummies to have into account some special circumstances (country's capital, harbours, and special regions). The t-statistics, between parentheses, show a high positive significance of parameters.

Equation 1. QNIH in 151 EU regions, year 2000

	LS	TSLS
QIH	1.66 (12.5)	2.14 (10.3)
Education	127.8 (10.3)	62.9 (19.1)
Tourism	262.7 (7.9)	263.5 (7.0)
Dummies +	Bruxelles, Hamburg, Île de France, Lazio, Luxembourg and Praha	
Dummy -	Eastern Europe	R <sup>2</sup> : LS=0.82, TSLS=0.77

Equation 2. QIH in 151 EU regions, year 2000

	LS	TSLS
QNIH	0.28 (13.5)	0.27 (11.7)
Education	7.58 (2.0)	62.9 (19.1)
Patents	7.13 (4.7)	7.43 (4.8)
Tourism	-57.64 (-3.2)	263.5 (7.0)
Dummies -	Bruxelles, Hamburg, Île Fr., Lux., Praha	
Dummy +	Navarra, Piemonte, other	R <sup>2</sup> : LS=0.65, TSLS=0.65

These results show the important impact that education, tourism and industry have generally on the development of other sectors (particularly in services and building). The results also show how tourism acts partially as substitute of industrial development, and how education, patents and the development of non manufacturing activities have also a positive impact on industrial development. Usually there is some lag between the increase in QNI and QI, so in a

pooled sample, with data of each region in several years, the system could be more recursive than interdependent, and LS estimation could be more adequate than TSLS.

Table 3 presents the estimated coefficients of the relationship between Gdp per head and RD expenditure per head by research sectors: Business (Bus), Government (Gov), Higher Education in Social Sciences and Humanities (SSH) and Higher Education in Natural Sciences and Engineering (NSE). Although the coefficients are affected by missing variables in the corresponding regressions, the results give support to a higher positive impact of the Higher Education Sector, particularly in SSH, on economic development.

Tabla 3. Coefficients of RD Expenditure by sector

Variable	Coef.	SD	t-stat	R <sup>2</sup>
rdhbus	0.4176	0.1014	4.12	0.9697
rdhgov	1.8466	0.3694	5.00	0.9695
rdhssh	7.7413	1.4313	5.41	0.9708
rdhnse	2.0556	0.4024	5.11	0.9698

Source: Guisan, Cancelo, Aguayo and Diaz (2001)

In Aguayo and Guisan(2004) and other studies cited in the bibliography we present other econometric models which show the important impact of these variables not only on Gdp per inhabitant but also on the territorial distribution of population and employment.

## 11. Conclusions

The interregional models of 151 EU regions here estimated show that human capital, together with industrial development and other variables, explain regional development in Europe. EU policies should be more addressed to diminish regional differences in human capital and income per inhabitant, fostering support to researchers particularly in the less favoured regions, not only in NSE but also in SSH, because this would be positive for regional development. In this regard it is important to have into account suggestions made by Fertig and Schmidt(2002): *“European Union will spend more effort*

*in supporting the development of more and better knowledge on issues decisive to the future development of European societies”.*

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Statistical sources: Eurostat (Main Regional Indicators) and OECD.

<sup>1</sup> articles available at: <http://www.usc.es/economet/welcomei.htm>

<sup>2</sup> articles available at: <http://ideas.repec.org> in ERSA series.