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Expenditure in R&D and local development: an analysis of Italian provinces

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ABSTRACT

Spending capacity in R&D is generally regarded as an important factor for the growth of modern economies. More important still is to understand the quality of the interaction between research resources and the single territories together with their concrete impact on innovation processes. The present level of aggregation of expenditure data on R&D, which is limited to administrative regions, is still high, this restricting the possibility to carry out more detailed analyses.

The aim of the present work, which is largely empirical, is to estimate the amount of R&D spending for different institutions in Italian provinces (University, Public Administration and Business). On the basis of these estimates, we have carried out some initial cross-analyses with variables relative to the provinces' different economic structures, current research findings and the impact on the wider economic context. The cluster analysis, in particular, has revealed the presence of seven profiles of innovation and territorial development which provide an approximate indication of the Italian provinces' different innovation resources and ability to respond to the competitive challenges posed by the international context.

Key-words: R&D, local development, innovation, cluster analysis
JEL classification: O32, O33, R11, R12

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1. EXPENDITURE ON RESEARCH AND DEVELOPMENT

During the last few years, it has been increasingly recognized that Research and Development (R&D), innovation and economic development are interrelated. An increase in R&D spending is regarded as an essential input for changing the economic structure of a country, increasing productivity and bringing about higher wages and a higher standard of living[1]. This has led researchers to measure the size of this variable and appraise its contribution to the growth of the national product. More recently, both national and regional policy makers have adopted R&D as one of their innovation policies targets. In fact, it is fairly common to find the ratio between R&D and Gross Domestic Product (GDP) among the target parameters of such policies. Over the past few years, the EU Councils of Ministers in Lisbon (2000) and Barcelona (2002), while announcing the general aim to transform the Union into an economy based on the most competitive knowledge in the world, have also identified one specific objective to achieve such aim, namely increasing the current expenditure on R&D from 1.9% to 3% by 2010[2]. Individual countries have also used this indicator to identify expenditure targets by setting a given percentage, as is the case with the EU, or by relating it to the values of the most advanced countries, or to the averages of member countries of international organisations such as OECD. The success of this indicator is due to its simple calculation and the existence, over the last few decades, of estimates and records widely available in almost every country[3].

Besides its recent success, one should be aware, in order to use it correctly, that the rising levels of expenditure on R&D are the result of socio-economic structural changes linked to the specific features of individual countries. For example, the economies that have rapidly reached a high level of development owing to high R&D intensities (Finland, Sweden, Iceland and Korea) are mostly small economies that started off ten-fifteen years ago from low

[1] See OECD (2003) for the international picture and Rossi (2003) for Italy.

[2] A critical evaluation of the feasibility of this objective and its necessary pre-conditions can be found in Sheehan-Wyckoff (2003).

[3] For example, OECD has collected data on R&D expenditure on a regular basis since 1968, while the Frascati's Manual on the measurement of the technical and scientific activities of the same organization is dated 1963 (see Sirilli 2000).

levels of investment and have grown thanks to investments by a small number of large multinational companies, i.e. Nokia and Ericsson. This development path cannot be easily generalised to every country.

Moreover, we must not forget that, to achieve the objective of rising expenditure, we need to implement coherent and consistent socio-economic policy measures in the areas of training, finance and market regulation together with area policies that facilitate such increase and strengthen its impact on the socio-economic system as a whole[4]. Without these measures, the identification of a given expenditure target as a proportion of GDP would be a mere expression of good intentions or simply a *desideratum*.

Furthermore, this indicator is limited in so far as it is a concept of input, involving the use of resources for given types of activities and says little on the effective dissemination of research findings and their impact on the entire economic system. In the linear sequence that starts with research and ends with the sale of the finished product and the end consumer, R&D spending stops at the first stages, when new knowledge is acquired mainly in laboratories equipped with dedicated staff, infrastructure and financial resources. This is the reason why this indicator does not measure innovation at the final, more variable stages of the invention-transformation-sale process. Moreover, the measure of R&D intensity is not very suitable for providing data on innovation occurring in business activities, business organization and trade, nor is it suitable for identifying the real role of small and medium enterprises in this process[5].

Expenditure on R&D is therefore to be considered as an important, but not a comprehensive element of a wider process of economic change stimulated by formalized, implicit knowledge and involving institutional and business players as well as large companies and small to medium enterprises.

2. R&D AND TERRITORY

Alongside the attention paid by researchers and policy makers to R&D spending, interest for the territorial dimension of technology innovation processes has been consolidating. In fact,

[4] On the impact of public spending on innovation at the regional level see Capriati (2004). For an overview of the research system in Italy see Scarda (2003).

[5] These limits have been partly addressed by the investigation of technology innovation carried out by Eurostat as part of the Community Innovation Survey and by the Research Statistical Institutes of EU countries, where the unit of analysis consists of companies operating in the manufacturing and services sectors.

regardless of the context in which it is met, higher spending on research and technology development does not guarantee the innovation growth of the economy. Research activities interact with a system of professional training, institutional and business structures and a production system capable of profiting from both the increased availability of formal research output (inventions, patents, models) and the informal, implicit knowledge that private and public research centres make available to the entire territory.

The territory therefore plays an important role in facilitating the spread of innovation. In the line of thought from Marshall (1920) to Arrow (1962) and in the analysis of Italian districts as well as the more recent contributions by Porter (1996, 2000), the territorial concentration of business activities facilitates the production of positive externalities of knowledge that can have beneficial effects on the innovation and development potential of an area. Such externalities are disseminated through the formal and informal contacts that are at the basis of the activity of territorial business networks. All available empirical evidence shows that a business' potential for innovation, particularly a small or a medium enterprise, is linked in the first place to its ability to co-operate with other businesses, i.e. companies learn better from other companies[6]. It is precisely because of the link between innovation and local business networks that the territorial dimension is so important. Knowledge does not travel well, especially for small and medium enterprises. In this approach, the distinction between codified and implicit knowledge plays a fundamental role[7]. The former can easily take the form of information that can be transferred at low costs, particularly in the present day and age thanks to the development of information and communication technologies. The latter, on the other hand, cannot be codified or formalized and can be transferred only by meeting costs that grow with distance. The direct relationship between different economic players consists in effective ways of transferring knowledge and producing positive externalities that enhance the potential for innovation and technology dissemination. Physical proximity improves the flow of technological knowledge, which involves business people, researchers, designers and the employees of a district[8].

In territorial contexts, an important role is played by institutions and their ability to model the environment in which different players interact within the innovation process. The importance

[6] Theoretical and empirical literature on this topic is wide-ranging. Besides the pioneer work of Becattini, Brusco and Garofoli (which we are not quoting in detail) see the work of Viesti (2000) and Signorini (2000).

[7] On these topics and more generally on local technological changes see Antonelli (1995).

[8] On the evolution of districts see the recent work of Cainelli-Zoboli (2003)

of local institutions in consolidating the potential for technology innovation is at the centre of regional innovation systems (RIS), these being based precisely on the generation and dissemination of technology innovation as a result of the continual interaction among different social, economic, and institutional players operating in the territory[9].

Regional players are also better placed to act on local knowledge, being aware of the companies' economic situation, the existing links and networks among companies, the quality of the local labour market, and the ability of the most important institutions to provide technical or commercial services[10].

It is only at the local level that a shared culture and the necessary synergies can develop more easily. Local environment is an important factor for the success or otherwise of a business, so much so that it can be regarded as an element of structural competitiveness.

The analyses of the regional systems of innovation concern the area of industrial concentration or industrial districts, whose geographical size can vary from individual municipalities to a multi-municipality aggregate[11]. The availability of statistical data on the main indicators of R&D and innovation, useful to make comparisons between different areas is however limited to the size of the administrative regions. In Italy ISTAT (Central Statistical Institute) disseminates data on R&D expenditure and information on business technology innovation relative to this dimension.

Trying to reduce the territorial scale of the information provided by statistical data is useful to narrow the gap between the territorial dimension of the process of technological change and the dynamics of local development.

The main aim of the present contribution is to put forward an estimate of R&D expenditure at provincial level and carry out some initial cross-analyses with a number of variables pertaining to provinces and concerning economic structure, innovation output and economic impact.

In attempting to make an estimate, the choice of level is justified for two main reasons, one concerns the statistical sources of data, the other concerns the characteristics of R&D

[9] Cook (2002), Braczyk et al (1998), Lundvall (2002), Archibugi-Lundvall (2001)

[10] On the role of local institutions on economic development see Arrighetti-Seravalli 1999 and Fadda 2001.

[11] On the various territorial aggregates and the geography of local development there is a large body of experimental studies, for all of them see the study carried out by IPI (2002)

expenditure. First of all, thanks to a number of public bodies and institutions[12], the present availability of economic data relating to provinces is no doubt greater and better organized as compared to a few years ago. This allows more reliable analyses at this territorial level. Secondly, as has been mentioned earlier, the characteristics of "expenditure on R&D" are such that it is necessary to refer it to activities carried out at Universities and the laboratories of large companies and public bodies, which have higher levels of investment in research infrastructure. This accumulation of capital has an impact that goes well beyond the municipal or inter-municipal level, as it may involve an inter-regional area. An analysis of R&D expenditure and its impact carried out at provincial level represents a good compromise between a restricted level (inter-municipal) and a large one (administrative regions or state).

3. ESTIMATING PROVINCIAL R&D SPENDING

As has been mentioned earlier, ISTAT makes available data on R&D spending by splitting it into institutional sectors (Public Administration, Universities and Business) and providing details about regions and national districts.

For our estimate we have prorated, for each province, the most recent regional data on R&D expenditure provided by ISTAT (2001) following these criteria:

- for Universities we have used data relating to lecturing staff (professors, senior lecturers, research fellows) employed by private and public Italian Universities[13];
- the expenditure estimate for research public bodies has been made on the basis of the distribution by province of the staff employed by such public bodies[14];
- business spending has been divided on the basis of the number of staff[15] employed by manufacturing and services companies with high and medium R&D intensities[16].

[12] It is worth mentioning in particular the efforts made by Unioncamere in collecting statistical data at provincial level as well as the commitment of ISTAT to enrich and expedite the availability of territorial public accounts at provincial level.

[13] See in particular MIUR (2003).

[14] In this case the sources of data are varied, in particular we have drawn on trade unions data bases, most recent brochures and the administrative sources of research public bodies, particularly ENEA (National Agency for the new Technologies, Energy and Environment) and CNR (National Research Council). This lack of uniformity of data is undoubtedly a weakness in the estimate of this component of R&D expenditure, which we hope to address in future studies.

[15] Source: ISTAT Census for industry and services, 2001.

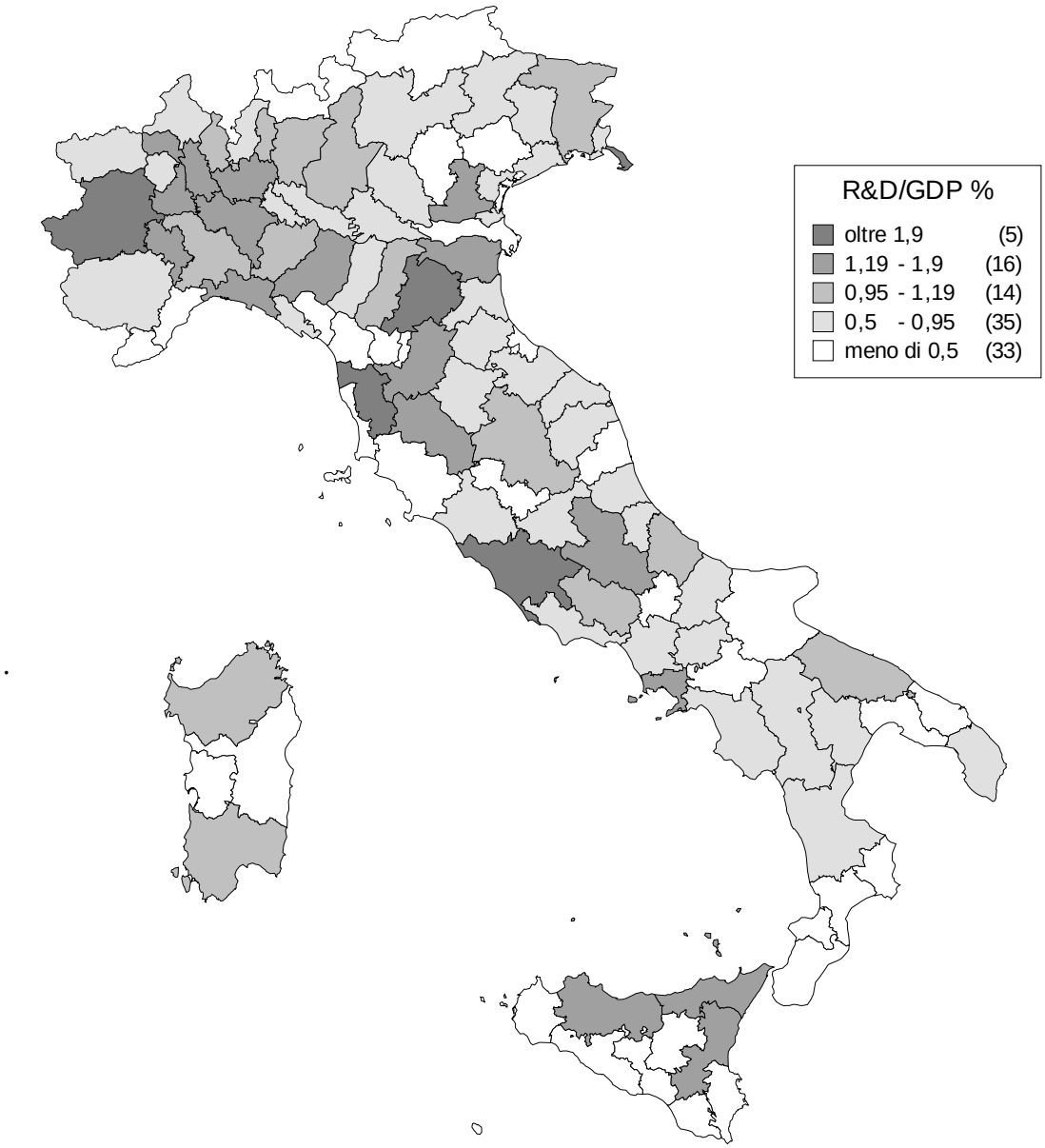
The estimated expenditure data on R&D has been related to provincial GDP, thus obtaining the classification presented in Table 1 and Map 1.

Table 1. Classification of Italian provinces by R&D intensity (year 2001).

code	Province	R&D/GDP %	code	Province	R&D/GDP %	code	Province	R&D/GDP %
53	PISA	3,50	22	TRENTO	0,93	45	FORLI'	0,51
33	TRIESTE	2,75	6	CUNEO	0,93	77	AVELLINO	0,45
65	ROMA	2,57	18	LODI	0,92	24	VICENZA	0,43
1	TORINO	2,43	40	REGGIO NELL'EMILIA	0,88	13	SONDRIO	0,42
42	BOLOGNA	2,10	3	BIELLA	0,86	46	RIMINI	0,36
17	PAVIA	1,88	4	VERBANO-CUSIO-OSSOLA	0,85	47	MASSA-CARRARA	0,36
55	SIENA	1,86	9	AOSTA	0,83	90	REGGIO DI CALABRIA	0,35
5	NOVARA	1,78	19	CREMONA	0,83	72	ISERNIA	0,35
2	VERCELLI	1,70	78	SALERNO	0,80	26	TREVISO	0,35
68	L'AQUILA	1,61	60	ANCONA	0,80	35	SAVONA	0,35
14	MILANO	1,52	30	PORDENONE	0,78	48	LUCCA	0,34
28	PADOVA	1,52	11	COMO	0,75	49	PISTOIA	0,33
93	MESSINA	1,52	59	PESARO E URBINO	0,73	79	FOGGIA	0,32
50	FIRENZE	1,49	20	MANTOVA	0,73	88	CATANZARO	0,32
43	FERRARA	1,45	73	CAMPOBASSO	0,72	52	LIVORNO	0,31
36	GENOVA	1,44	84	POTENZA	0,68	99	SIRACUSA	0,31
39	PARMA	1,41	61	MACERATA	0,67	51	PRATO	0,28
97	CATANIA	1,40	25	BELLUNO	0,66	21	BOLZANO	0,26
7	ASTI	1,36	63	VITERBO	0,65	56	GROSSETO	0,22
92	PALERMO	1,34	85	MATERA	0,64	58	TERNI	0,21
76	NAPOLI	1,33	74	CASERTA	0,63	91	TRAPANI	0,20
8	ALESSANDRIA	1,16	64	RIETI	0,61	29	ROVIGO	0,19
10	VARESE	1,14	86	COSENZA	0,60	102	ORISTANO	0,18
67	FROSINONE	1,09	83	LECCE	0,59	62	ASCOLI PICENO	0,18
71	CHIETI	1,07	27	VENEZIA	0,59	95	CALTANISSETTA	0,18
57	PERUGIA	1,06	32	GORIZIA	0,57	34	IMPERIA	0,17
31	UDINE	1,06	44	RAVENNA	0,57	82	BRINDISI	0,16
41	MODENA	1,05	75	BENEVENTO	0,56	81	TARANTO	0,14
16	BRESCIA	1,05	69	TERAMO	0,54	94	AGRIGENTO	0,13
15	BERGAMO	1,04	66	LATINA	0,54	98	RAGUSA	0,13
38	PIACENZA	1,02	23	VERONA	0,52	96	ENNA	0,12
80	BARI	1,00	54	AREZZO	0,52	87	CROTONE	0,07
12	LECCO	0,97	70	PESCARA	0,52	89	VIBO VALENTIA	0,07
103	CAGLIARI	0,96	37	LA SPEZIA	0,51	101	NUORO	0,05
100	SASSARI	0,96						

[16] According to OECD, the manufacturing industries with medium-high R&D intensities are: pharmaceuticals (code ATECO 24.4); air-crafts (35.3); office equipment and computers (30); radio and television and communications (32); precision and optical instruments (33); electrical equipment (31); motor vehicles (34); chemicals (24, except pharmaceuticals); locomotives (35.2); other means of transport (35.5); machinery and mechanical equipment manufacturing (29). The services with the highest R&D intensity are instead: post and telecommunications (64); IT and related activities (72) and research and development (73).

Map 1. Italian provinces grouped by R&D intensity.



The classification reported in Table 1 highlights the presence of four groups of provinces:

- the first (high intensity) consists of five provinces with R&D intensities higher than the EU average (1.9%);

- the second (medium-high intensity) consists of 16 provinces with indices lower than the EU average but higher than the national average (1.19%);
- the third (medium intensity) consists of 14 provinces with values lower than the national average but higher than half of the EU average (0.95%);
- the fourth (low intensity) consists of 68 provinces with indices lower than the latter threshold.

In Italy, R&D intensity is territorially concentrated in one group of leading provinces and a restricted band of provinces with medium and medium-high indices. The group composed of the five provinces with the highest R&D intensity comprises areas with very large cities (Rome, Turin and Bologna) and areas with medium-sized cities (Pisa, Trieste) [17]. In almost all these provinces (except Turin) the weight of business R&D spending on the total spending is lower than the national average percentage, this indicating the predominance of public structures, universities and research institutes. The presence of large companies is also high (higher than the national average) (except Pisa), so is the number of companies with medium-high R&D intensities (except Pisa and Trieste) and of business groups (except Pisa). As we shall see, these and other differences to be analysed later, place these leading provinces in groups with different economic and innovation profiles. Of note is the particular position of the province of Pisa where the research activity, financed by R&D spending and as high as the "Finnish" levels, does not seem to attract high tech businesses and large industrial groups. This characteristic seems to affect also the productivity level, this being lower than the national average. The employment rate and average income of all the five provinces with high R&D intensities are, instead, above the national average.

The group with medium-high R&D intensities appears to be more composite. In the first place, the Milanese province is peculiar in so far as its profile is affected by the presence of high tech companies and large industrial groups. This is associated with indicators of product per employee, employment rate and average income higher than any Italian province, together with a great capacity for transforming research activity into codified results.

A second subgroup is made up of provinces, such as Padua, Florence, Ferrara and Parma, which show a great capacity for producing research output within an economic structure characterized by high public investment and (except for Parma) fewer high tech companies and industrial groups.

[17] In this section we shall refer to other indicators besides R&D data, which can be viewed in Table 3.

A third subgroup is composed of southern provinces with medium-high R&D intensities: L'Aquila (being the tenth nationally and the first in the south in this classification), Messina, Naples, Catania and Palermo. These provinces share some important features. The quota of R&D investments by private businesses is considerably lower than the national average; significant is the presence of large companies, but there are few high tech businesses and industrial groups; whereas all the other indicators of output, productive efficiency, openness to foreign trade, income level and employment rate are consistently lower than the national average[18].

Within the group of provinces with medium R&D intensities we can identify two subgroups. The first is made up of medium-sized provinces in the centre-north: Varese, Modena, Udine, Alessandria, Bergamo, Lecco and Brescia, as well as Chieti; this group is characterized by the significance of private spending - higher than the average - vis-à-vis public spending. This distinctive feature is associated with the significant presence of sectors with a medium-high capacity for innovation, but at the same time the low presence of large companies and industrial groups. In many of these provinces the capacity to issue patents is significant, with indices in most cases close to or higher than average. All the other indicators are generally higher than the national average.

The second subgroup is composed of the southern provinces of Bari, Sassari, Cagliari and the central ones of Viterbo and Perugia. In these provinces the public component is clearly dominant and all the other indicators are below the national average. This group differs from the one comprising southern provinces with medium-high R&D spending capacity because of the absence of large companies, which play a decisive role in the previous subgroup.

4. CORRELATION ANALYSIS

The data relating to R&D spending has been associated with a number of indicators that allow an in depth analysis of the position of each province:

1. a schooling index, calculated as percentage weight of the population with a certificate of compulsory schooling on the total number of inhabitants between 15 and 52 years of age;
2. percentage weight of the number of employees in large companies (+ 250 employees) on the total of provincial employees;

[18] (except for foreign trade in the province of L'Aquila)

3. percentage weight of the number of employees in sectors with medium-high R&D intensities;
4. percentage weight of employees in business groups on the total number of provincial employees[19];
5. a synthetic indicator of research output, obtained as a simple average of the normalized indices for the national average of the ratio between patents filed in the European Patent Office, inventions, models (decorative and functional), trademarks deposited in the Chambers of Commerce[20], as a proportion of the population;
6. product per employee;
7. degree of openness to foreign trade[21] (calculated as the ratio between exports and manufacturing value added);
8. employment rate (calculated on the total population);
9. value added per capita [22].

The ratio between R&D expenditure and GDP and index 1 can be regarded as *research input* indicators; indices 2, 3 and 4 describe, instead, the province's *productive structure* with reference to the sector's structure, size and type of ownership; index 5 tries to capture the intensity of *research output* at provincial level; while the latter four indices capture the *performance* of the local economy in terms of income, employment, productivity and openness to foreign trade.

[19] On the role of the industrial groups in the Italian economy, particularly in the districts, see Brioschi-Cainelli (2001).

[20] The data have been taken from the statistical appendix of Unioncamere 2004.

[21] On the problems of market openness, accumulation of knowledge and local development see Conti-Menghinello (2002)

[22] All the data refer to 2001.

Table 2 – Correlation matrix[§]

	R&D expend. /GDP %	*Schooling percentage*	*Proportion of large companies*	*Proportion of high tech businesses*	*Proportion of industrial group*	*Innovation output*	*Product per employee*	*Export /Value added ratio*	*Employm. rate*	*GDP per capita*
R&D expend./GDP %	1,00	0,29**	0,58**	0,49**	0,63**	0,44**	0,49**	0,19	0,27**	0,39**
Schooling percentage	0,29**	1,00	0,08	0,43**	0,51**	0,47**	0,59**	0,45**	0,73**	0,73**
Proportion of large companies	0,58**	0,08	1,00	0,41**	0,57**	0,21*	0,35**	0,04	0,01	0,16
Proportion of high tech businesses	0,49**	0,43**	0,41**	1,00	0,67**	0,55**	0,66**	0,64**	0,46**	0,58**
Proportion of industrial group	0,63**	0,51**	0,57**	0,67**	1,00	0,65**	0,78**	0,51**	0,63**	0,76**
Innovation output	0,44**	0,47**	0,21*	0,55**	0,65**	1,00	0,59**	0,50**	0,64**	0,70**
Product per employee	0,49**	0,59**	0,35**	0,66**	0,78**	0,59**	1,00	0,52**	0,64**	0,84**
Export/Value added ratio	0,19	0,45**	0,04	0,64**	0,51**	0,50**	0,52**	1,00	0,59**	0,61**
Employment rate	0,27**	0,73**	0,01	0,46**	0,63**	0,64**	0,64**	0,59**	1,00	0,95**
GDP per capita	0,39**	0,73**	0,16	0,58**	0,76**	0,70**	0,84**	0,61**	0,95**	1,00

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

[§] for a more detailed description of the variables see section 4.

The correlation matrix reported in Table 2 highlights a high correlation of the selected variables. A significant (0.01) and high correlation (greater than 0.5) is found in the majority of cases, particularly in the variable that measures the weight of business groups (nine cases out of nine), product per employee (seven out of nine), product per capita (seven out of nine), employment rate (six out of nine) openness to foreign trade (six out of nine) and the indicator of innovation output (six out of nine).

The indices relating to the two input indicators (R&D spending and schooling) are significant but not high; whereas the weight of large companies is generally poorly correlated with the

other variables, with significant and high indices only for R&D spending and weight of business groups.

5. CLUSTER ANALYSIS

A cluster analysis of similar provinces has been carried out on the basis of the group of indicators described in the previous section. The proposed grouping is based on seven groups (see Table 3). The first is composed of the provinces with the two largest Italian cities: Milan and Rome whose characteristics are clearly different from those of the other Italian provinces for all indicators, particularly for intensity of R&D spending, presence of large companies, business groups, innovation output and income per capita. The two metropolitan provinces are however different in so far as Milan enjoys a better position particularly as regards the ratio between exports and industrial value added as well as the presence of high tech businesses. On the other hand, the Roman province is characterized by higher indices for R&D investment and the presence of large companies and business groups.

The second group (cluster B in Table 3) comprises 15 provinces that can be considered as leaders in the Country's innovation processes. They are all placed in the centre-north of Italy: four Piedmontese provinces (including the regional capital), four Lombard provinces, two Venetian and two Emilian ones (with Bologna), besides the regional capitals of Florence, Trieste and Ancona. This group is characterized by R&D spending and economic performance on average[23] higher than the national average, as well as very high openness to foreign trade and good indicator values for innovation output and high tech businesses.

This group is obviously composite as it includes large cities (Turin, Bologna, Florence) and medium-sized provinces which have made the recent history of Italian industrialization.

In these first two groups (A and B) high R&D spending seems to be linked on the one hand to good levels of innovation output and the presence of innovative companies and on the other to positive indicators of economic performance (employment, productivity and income).

Group C is characterized, instead, by low R&D spending but indices of performance and innovation output higher than the national average; in particular openness to foreign trade is very high in these provinces, equal, in the group's average, to 48.3% (against the national average of 22.6%), the highest among the clusters examined.

[23] We are referring here to the average of the group, calculated as simple average of the provinces' indicators.

In the ten provinces of this group, almost all in the centre-north-east of the Country, the process of innovation and development seems to be pulled by foreign markets relations more than being the result of a particular concentration of research resources. The productive structure of these provinces is based on the small and medium enterprises of the industrial districts, as shown by the indices indicating a low number of large companies and business groups.

The fourth group (D) is composed of 22 provinces, almost all of them in the centre-north regions (except for L'Aquila, Isernia and Siracusa). It has performance indices on average equal to national averages, with the exception of openness to foreign trade which is higher. This group's profile is not very different from the previous one but it appears to be less successful, being characterized by lower levels of innovation output, income and employment.

The fifth group (E) is made up of 21 provinces almost all in the centre-north (except for Teramo) with income per capita, productivity and employment rate on average higher than the national average. All the other indices are very low, in particular the ones relative to the presence of large companies, business groups, innovation output and openness to foreign trade. Unlike the previous two groups, mainly in the centre-north, the distinctive feature of this group's profile is its weakness in foreign markets. Group E is also the most variegated among those proposed in the cluster analysis: it comprises, in fact, provinces with important Universities and research centres which push the indices of R&D spending to levels higher than the national average, this being the case of Pisa, Siena, Genoa and Ferrara.

The last two groups consist almost entirely of southern provinces and are characterized by indices on average lower than the national average. Group F comprises 11 provinces that can be defined *at an intermediate level of economic development*, characterized by indices of R&D spending, openness to foreign trade, presence of large companies and high tech sectors less far from the national average, as compared to group G.

The latter group, which can be defined *lagging behind provinces*, is, instead in all cases, very far from average national values. Among the 11 provinces belonging to group F, there are some with metropolitan areas such Naples, Bari, Palermo, Catania and Cagliari. In these cases, thanks to the presence of large Universities and research centres, R&D spending is close to or higher than one per cent of GDP.

Table 3 – Results of the cluster analysis*.

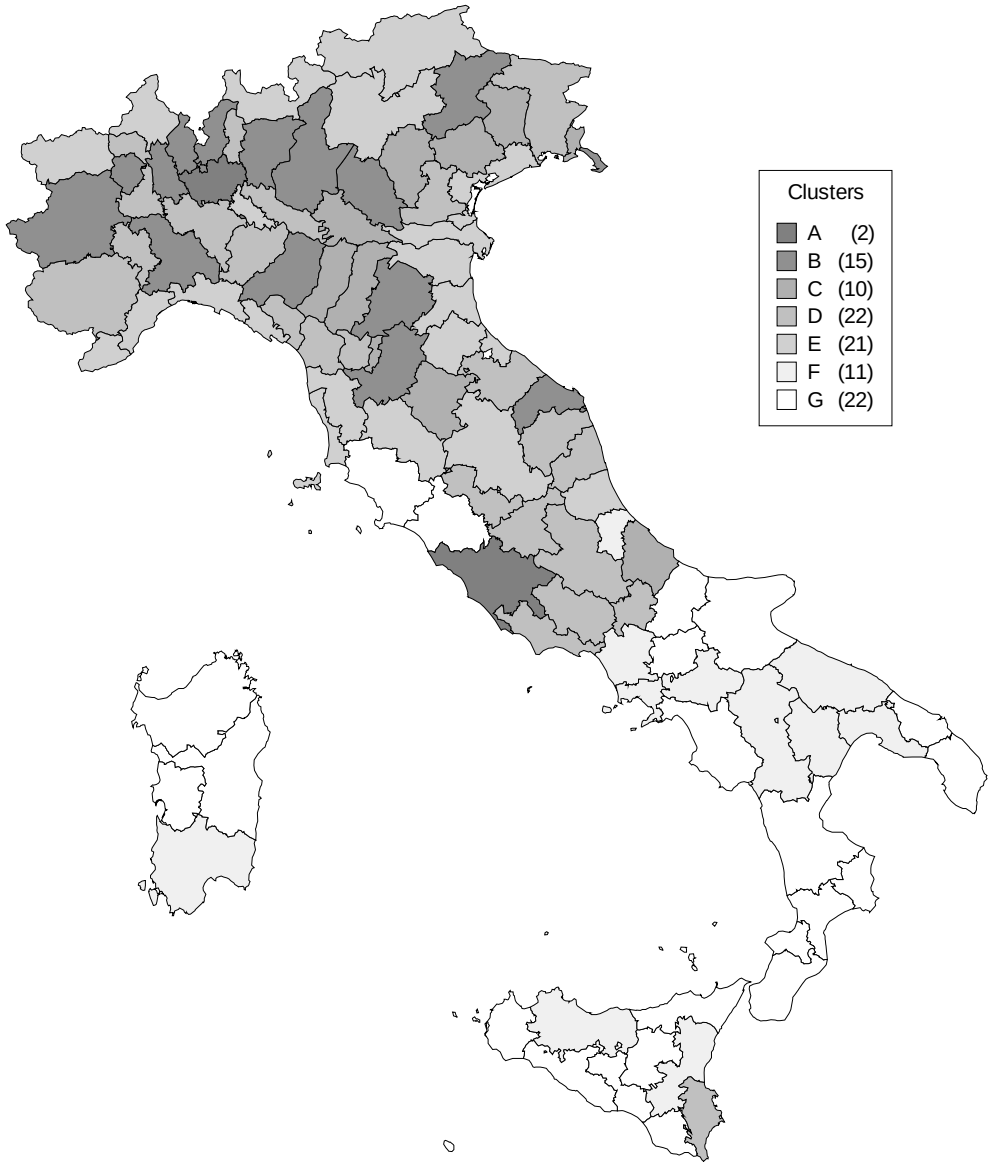
Province	Cluster	Distance from the centre of the group	R&D expend. /GDP %	Schooling percentage	Proportion of large companies	Proportion of high tech businesses	Proportion of industrial group	Innovation output	Product per employee	Export /Value added ratio	Employm. rate	GDP per capita
MILANO	A	14,81	1,52	92,95	18,7	17,5	63,4	3,44	59,0	30,8	53,8	31,8
ROMA	A	14,81	2,57	93,96	27,6	11,2	68,6	1,40	53,9	6,4	46,2	24,9
Media gruppo A			**2,04**	**93,46**	**23,16**	**14,35**	**66,00**	**2,42**	**56,47**	**18,56**	**50,03**	**28,35**
TORINO	B	18,29	2,43	92,36	20,6	19,6	49,5	2,49	51,8	29,3	46,1	23,9
BIELLA	B	8,66	0,86	88,95	11,8	8,1	30,2	0,36	48,9	35,1	46,5	22,7
NOVARA	B	13,33	1,78	89,5	11,7	17,2	42,4	0,45	49,7	40,3	45,5	22,6
ALESSANDRIA	B	8,02	1,16	91,64	11,6	11,5	28,4	0,68	50,2	26,9	45,3	22,7
VARESE	B	8,49	1,14	90,43	12,5	14,6	29,1	1,01	51,0	35,9	42,6	21,7
COMO	B	11,60	0,75	90,32	8,2	9,7	30,4	0,87	50,8	38,3	42,7	21,7
BERGAMO	B	6,95	1,04	89,93	11,1	13,9	34	0,74	49,5	37,3	45,9	22,7
BRESCIA	B	8,13	1,05	89,97	10,2	12,4	28	1,06	49,5	27,9	48,5	24,1
VERONA	B	9,33	0,52	91,43	13,5	9,9	26,1	1,24	47,4	32,0	48,4	22,9
BELLUNO	B	13,44	0,66	92,32	16,9	25,8	34,1	0,69	48,4	35,4	48,8	23,6
TRIESTE	B	21,79	2,75	95,54	21,8	8,9	44	0,69	51,8	15,1	47,5	24,6
PARMA	B	6,66	1,41	92,71	15,3	12,8	33,5	1,48	51,8	28,2	51,5	26,6
BOLOGNA	B	11,39	2,10	93,55	15,2	16,7	41,4	3,57	54,1	29,5	51,3	27,8
FIRENZE	B	9,93	1,49	91,76	12,8	10,9	28,7	2,17	50,8	25,3	51,5	26,2
ANCONA	B	6,81	0,80	92,12	13,1	14,3	28,8	1,16	48,2	33,2	44,6	21,5
Media gruppo B			**1,33**	**91,50**	**13,76**	**13,75**	**33,91**	**1,24**	**50,26**	**31,31**	**47,11**	**23,69**
MANTOVA	C	7,52	0,73	90,07	12,0	11,4	23,3	0,69	49,0	42,4	48,1	23,6
VICENZA	C	11,18	0,43	91,71	7,9	14,6	28,9	1,90	47,5	58,2	50,6	24,0
TREVISO	C	4,01	0,35	91,67	8,3	12,0	24,3	1,61	47,2	45,3	47,8	22,6
PORDENONE	C	5,56	0,78	93,22	11,1	13,3	30,1	1,91	47,2	46,1	46,6	22,0
GORIZIA	C	13,96	0,57	94,78	12,6	10,3	30,8	0,39	46,7	60,1	44,9	21,0
REGGIO EMIL.	C	13,44	0,88	90,58	9,5	16,0	38,3	1,32	47,5	47,3	51,8	24,6
MODENA	C	10,91	1,05	90,37	11,2	15,2	31,8	1,93	51,0	45,5	53,5	27,3
PRATO	C	13,15	0,28	87,95	2,9	5,5	19,3	0,83	47,7	45,6	51,7	24,7
AREZZO	C	10,77	0,52	92,46	7,0	6,5	18,4	1,16	43,8	46,8	47,4	20,7
CHIETI	C	16,25	1,07	90,15	15,8	13,1	17,8	0,47	41,4	46,1	39,4	16,3
Media gruppo C			**0,66**	**91,30**	**9,82**	**11,79**	**26,30**	**1,22**	**46,91**	**48,35**	**48,17**	**22,68**
VERCELLI	D	11,21	1,70	88,97	13,3	12,8	20,2	0,57	48,2	35,7	45,4	21,9
CUNEO	D	9,76	0,93	90,78	13,5	9,9	20,1	0,59	47,6	32,0	47,6	22,7
ASTI	D	7,93	1,36	89,76	7,2	14,1	18,4	0,62	47,9	21,3	43,1	20,6
LECCO	D	10,42	0,97	91,53	6,5	13,7	19,3	0,92	51,2	35,2	42,4	21,7
PAVIA	D	4,41	1,88	90,4	10,2	12,2	18,6	0,61	49,0	25,6	39,8	19,5
CREMONA	D	7,23	0,83	90,26	10,2	11,1	17,7	0,66	50,5	21,8	41,0	20,7
PADOVA	D	8,88	1,52	92,1	10,0	13,2	21,9	2,07	47,5	27,7	47,7	22,6
UDINE	D	6,82	1,06	92,76	9,1	10,6	19,9	2,21	46,4	29,8	46,7	21,6
PIACENZA	D	8,18	1,02	92,74	7,4	11,4	17	0,64	50,2	21,2	42,7	21,4
MASSA-CARRA	D	10,03	0,36	92,23	5,3	7,1	11,4	0,43	45,3	27,7	36,7	16,6
LUCCA	D	7,97	0,34	91,16	5,7	7,1	19	0,75	48,7	32,7	43,6	21,3
PISTOIA	D	8,88	0,33	88,54	3,2	6,6	16,8	0,65	44,5	24,8	45,4	20,2
TERNI	D	9,52	0,21	93,85	10,3	7,2	25,1	0,26	46,3	24,0	39,7	18,4
PESARO E URB	D	7,16	0,73	92,2	6,1	8,9	19,3	0,88	42,5	24,7	45,3	19,3
MACERATA	D	9,07	0,67	89,95	6,4	6,1	14,9	2,42	41,9	24,6	45,7	19,2
ASCOLI PICENO	D	7,21	0,18	91,07	5,4	6,9	15,6	0,36	42,6	27,9	44,1	18,8
RIETI	D	12,52	0,61	92,19	9,2	11,9	9,2	0,38	46,5	29,4	33,9	15,7
LATINA	D	6,64	0,54	88,97	11,9	11,6	21,9	0,18	45,2	24,0	41,7	18,9
FROSINONE	D	11,80	1,09	88,45	14,2	15,2	22	0,43	48,8	28,3	34,3	16,7
L'AQUILA	D	11,12	1,61	92,51	14,9	13,2	13,7	0,31	42,5	24,7	37,0	15,7
ISERNIA	D	8,05	0,35	89,87	7,9	7,2	19,5	0,42	43,6	22,2	38,8	16,9
SIRACUSA	D	16,93	0,31	85,54	9,4	8,2	11,9	0,08	46,3	38,5	32,7	15,1
Media gruppo D			**0,85**	**90,72**	**8,97**	**10,29**	**17,88**	**0,75**	**46,51**	**27,45**	**41,61**	**19,35**

* For a more detailed description of the variables see section 4.

Table 3 (continued)

Province	Cluster	Distance from the centre of the group	R&D expend. /GDP %	Schooling percentage	Proportion of large companies	Proportion of high tech businesses	Proportion of industrial group	Innovation output	Product per employee	Export /Value added ratio	Employm. rate	GDP per capita
VERBANO-CUSI	E	7,52	0,85	89,66	5,7	7,4	18,5	0,39	45,8	15,7	41,8	19,1
AOSTA	E	11,17	0,83	91,31	10,0	7,7	30,4	0,28	48,9	12,4	50,3	24,6
SONDRIO	E	6,72	0,42	92,37	7,5	6,6	19,3	0,21	47,7	11,3	43,1	20,5
LODI	E	12,26	0,92	90,67	6,8	15,8	19,2	0,53	52,4	18,4	39,9	20,9
BOLZANO	E	13,66	0,26	91,27	9,3	7,0	24,7	0,81	49,3	15,4	57,6	28,4
TRENTO	E	6,65	0,93	94,22	9,0	8,6	17,2	0,51	50,4	17,4	48,2	24,3
VENEZIA	E	11,35	0,59	91,26	14,0	8,8	24,3	0,55	48,6	25,4	47,9	23,3
ROVIGO	E	11,34	0,19	89,48	7,9	6,7	11,8	0,39	44,2	16,1	42,7	18,8
IMPERIA	E	16,16	0,17	90,52	3,4	4,0	12,2	0,47	46,9	4,7	46,1	21,6
SAVONA	E	9,49	0,35	92,91	7,9	7,2	14,1	0,65	48,7	10,1	45,7	22,3
GENOVA	E	17,51	1,44	93,5	18,1	9,7	33,1	0,83	52,8	10,6	41,8	22,1
LA SPEZIA	E	11,33	0,51	93,72	12,5	6,5	21,1	0,32	50,6	7,0	41,9	21,2
FERRARA	E	8,92	1,45	90,55	13,5	13,6	23,5	0,87	45,1	19,7	44,4	20,0
RAVENNA	E	7,46	0,57	92,75	10,1	9,3	22,6	1,20	45,5	20,1	51,7	23,5
FORLI'	E	9,07	0,51	92,15	9,9	7,9	19,2	0,68	44,0	22,9	50,8	22,4
RIMINI	E	11,29	0,36	93,24	5,5	7,6	16,4	1,10	44,4	15,9	55,0	24,4
LIVORNO	E	5,81	0,31	92,1	11,8	7,1	17,7	0,36	47,9	13,2	43,8	21,0
PISA	E	11,63	3,50	90	10,9	8,9	28	1,46	47,1	24,3	45,0	21,2
SIENA	E	12,46	1,86	91,16	11,7	7,6	31,6	0,55	43,8	20,5	49,0	21,4
PERUGIA	E	6,13	1,06	92,91	8,5	7,6	18,9	0,68	44,4	11,6	45,2	20,1
TERAMO	E	11,05	0,54	91,15	5,5	6,8	18,9	0,47	39,5	20,2	44,5	17,6
Media gruppo E			**0,84**	**91,76**	**9,50**	**8,20**	**21,08**	**0,63**	**47,04**	**15,85**	**46,49**	**21,84**
PESCARA	F	10,26	0,52	92,29	11,2	7,5	15,7	0,76	46,6	7,4	37,7	17,6
CASERTA	F	5,93	0,63	85,97	11,7	10,4	12,6	0,12	41,8	8,5	30,0	12,5
NAPOLI	F	9,06	1,33	81,92	19,6	8,3	20	0,30	43,6	11,1	29,6	12,9
AVELLINO	F	6,33	0,45	89,43	10,0	9,7	14,5	0,12	40,4	11,4	34,8	14,1
BARI	F	8,72	1,00	83,13	13,2	7,4	23,1	0,34	40,8	12,6	34,1	13,9
TARANTO	F	10,03	0,14	85,24	21,7	5,2	10,6	0,10	41,3	10,8	32,5	13,5
POTENZA	F	10,57	0,68	88,15	14,9	12,9	18,5	0,14	44,8	19,0	31,5	14,1
MATERA	F	9,05	0,64	89,31	7,7	5,4	13,3	0,23	39,2	11,9	35,2	13,8
PALERMO	F	12,99	1,34	82,49	17,6	7,0	22,4	0,18	46,4	2,7	28,1	13,0
CATANIA	F	6,48	1,40	85,01	12,8	7,8	12,3	0,27	43,4	5,9	30,6	13,3
CAGLIARI	F	7,02	0,96	88,4	12,2	6,8	11,1	0,21	43,4	14,5	34,1	14,8
Media gruppo F			**0,83**	**86,49**	**13,87**	**8,05**	**15,83**	**0,25**	**42,89**	**10,54**	**32,57**	**13,95**
GROSSETO	G	12,42	0,22	90,71	5,9	4,8	5,3	0,26	40,6	4,3	43,8	17,8
VITERBO	G	7,30	0,65	90,97	5,8	3,8	6,4	0,37	41,7	5,9	37,0	15,4
CAMPOBASSO	G	7,97	0,72	90,5	11,8	8,8	5,8	0,17	43,1	5,9	35,2	15,2
BENEVENTO	G	6,43	0,56	89,13	5,5	5,2	3,1	0,12	36,5	2,2	33,7	12,3
SALERNO	G	7,80	0,80	88,96	8,9	5,5	10,3	0,14	40,4	10,1	32,9	13,3
FOGGIA	G	5,64	0,32	83,42	11,6	5,4	7,5	0,12	37,3	3,6	31,7	11,8
BRINDISI	G	8,08	0,16	85,08	9,0	6,0	4,4	0,12	37,7	10,9	34,5	13,0
LECCE	G	8,14	0,59	87,19	10,4	4,1	12,1	0,12	36,6	8,1	32,3	11,8
COSENZA	G	8,55	0,60	85,95	10,4	4,7	13,9	0,12	38,6	0,5	31,9	12,3
CROTONE	G	8,41	0,07	82,24	7,7	3,9	6,3	0,07	40,5	1,3	27,3	11,1
CATANZARO	G	5,18	0,32	86,21	11,4	5,4	6,5	0,24	42,3	0,5	33,6	14,2
VIBO VALENTIA	G	5,44	0,07	86,67	5,8	3,9	4,7	0,06	36,4	2,3	32,1	11,7
REGGIO CAL.	G	8,05	0,35	87,39	14,9	5,1	3,2	0,12	38,8	1,5	30,7	11,9
TRAPANI	G	7,03	0,20	84,96	3,1	4,4	3,4	0,14	39,9	3,5	31,3	12,5
MESSINA	G	7,71	1,52	89,39	15,2	4,8	8,7	0,13	41,5	3,6	33,6	14,0
AGRIGENTO	G	7,73	0,13	84,42	7,6	3,7	7,5	0,08	40,2	0,7	27,4	11,0
CALTANISSETT	G	10,59	0,18	82,15	9,7	4,8	8,9	0,57	44,9	6,9	26,6	12,0
ENNA	G	6,42	0,12	86,72	10,4	3,3	3,7	0,04	36,7	0,8	30,9	11,3
RAGUSA	G	6,46	0,13	83,63	7,1	3,7	4,6	0,17	37,9	1,8	37,5	14,2
SASSARI	G	7,51	0,96	87,03	9,9	5,5	8,2	0,16	40,6	4,4	39,8	16,2
NUORO	G	5,20	0,05	88,51	5,3	4,8	7,5	0,05	40,9	1,8	35,5	14,5
ORISTANO	G	7,73	0,18	87,42	3,9	3,7	1,4	0,03	40,3	1,9	35,5	14,3
Media gruppo G			**0,40**	**86,76**	**8,69**	**4,79**	**6,52**	**0,15**	**39,70**	**3,75**	**33,39**	**13,26**
Totale			**1,19**	**89,56**	**13,6**	**11,1**	**31,9**	**1,00**	**47,8**	**22,6**	**41,8**	**20,0**

Map 2 – Italian provinces grouped by cluster.



Caption for clusters

A = Provinces including large metropolitan areas

B = Leading provinces

C = Provinces with high openness to foreign trade

D = Non-innovative provinces with a fair degree of openness to foreign trade

E = Non-innovative provinces with good economic performance

F = Provinces at an intermediate level of economic development

G = Lagging behind provinces

6. CONCLUSIONS

The analysis of the intensity of R&D spending has highlighted its high territorial concentration: a relatively limited number of provinces (35) present values that are above a minimum acceptable level, as compared with Europe (half of the EU-15 average).

This top group is in turn particularly variegated; it includes the provinces with the metropolitan areas of the centre-north (Milan, Turin, Rome, Bologna, Florence, Genoa); the provinces where large cities are absent and the university/public research profile prevails, in some cases with an old tradition (Pisa, Trieste, Pavia, Siena, Padua, Ferrara, Perugia); a group of provinces placed mainly in the middle band of the classification by R&D intensity (Varese, Modena, Udine, Alessandria, Bergamo, Lecco, Brescia, Asti) where the most significant quota of R&D is largely fulfilled by small and medium enterprises; finally nine southern provinces (Naples, Catania, Palermo, Messina, Chieti, Bari, Cagliari, Sassari and L'Aquila) where public R&D spending is higher than the national average.

The cluster analysis, carried out by associating other indicators of economic structure, research and human capital input, innovation output and economic performance, has allowed to highlight different models of innovation and territorial development.

A particular role is played by two *large metropolitan areas*, i.e. Milan and Rome, which, for the impact of their size and intensity of the phenomena under exam, play a role on a national scale in industrial processes and in the offer of advanced services. These large centres are the privileged central headquarters of large national and foreign groups as well as nodes of international importance in the large networks of private and public services. In these two provinces the high level of R&D spending, which derives from such particular position, is strictly linked to a higher innovation capacity and better income and employment conditions.

The four groups comprising almost all the other provinces of the centre-north (clusters B, C, D, E) describe four different types of territorial development: the first (B, *leading provinces*), including medium and large provinces, is based on high R&D spending, the presence of high tech companies, business groups, innovation output and openness to foreign markets. This profile achieves an excellence performance of the indicators immediately after Rome and Milan.

The second cluster (cluster C, *provinces with high openness to foreign trade*) is characterized by the high presence on foreign markets and extremely low R&D spending. Their good performance in terms of innovation output, income and employment seem therefore to derive

mainly from the stimulus provided by international competition more than from appropriate policies of public and private investment.

As for the third group of provinces in the centre-north (cluster D, *non-innovative provinces with a fair degree of openness to foreign trade*), the relative openness to foreign trade does not seem to have produced the positive effects present in the previous group.

The fourth group (cluster E, *non-innovative provinces with good economic performance*) includes small- and medium-sized provinces in the centre-north, some of which with a longer industrial history, whose presence on foreign markets is limited as is the presence of innovative companies.

These latter groups of provinces (largely small- and medium-sized) represent three variations of the development based on small and medium enterprises territorial systems; in the most recent conjuncture they are facing the competitive pressure from Asian countries and the disadvantages deriving from the new monetary context. Owing to low investment in R&D activities and a limited presence of high tech businesses, the chances that they may come out of this difficult phase seem to be particularly onerous and complex.

The last two types of innovation and territorial development include almost all the southern provinces. These two clusters (F, G) reach levels of economic performance clearly lower than the other groups. The first of the two (F, *provinces at an intermediate level of economic development*) differs from the second (G, *lagging behind provinces*) for the higher presence of large companies, high tech sectors and industrial groups. Productivity and openness to foreign markets are also higher. Undoubtedly the presence of the largest metropolitan centres in the south with significant quotas of public investment in R&D and a few important private companies benefit the southern provinces at an intermediate level of economic development. The cyclical difficulties mentioned above together with a poor innovation capacity, which characterizes also the southern provinces, will make it even more difficult to rise to the challenges posed by competition.

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