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The concentration of knowledge activities in Italy. An analysis at local level

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1. *Introduction*

Scientific and technical infrastructures are usually rooted into specific geographical contexts and their potential is largely affected by its features[1]. Among them, research and development (R&D) activities are typically spatially concentrated at a sub-regional level where local factors provide competitive advantages in terms of access to services and potential for spillovers. As spillovers are made possible by contiguity among R&D performers, they tend to cluster in specific areas.

The extensive literature on the regional localization of R&D activities, mainly aimed at developing empirical foundations for research and innovation policies at regional level, has usually neglected the analysis of R&D localization at sub-regional level (e.g. municipal, provincial/county level). The lack of highly detailed data on the geographical distribution of R&D activities has lead to highlight related, but different, phenomena of the R&D performance: the sectoral distribution of R&D activities, enterprises' research strategies, public-private co-operation on R&D, etc. One of the most relevant issues discussed in the literature is to what extent activities carried out in public research and higher education institutions, as well as in high-tech firms, produce positive spillovers in the area where they are located. All these analyses are focusing, in most cases, on a small number of case studies because of the limited availability of comprehensive datasets on R&D performed at sub-regional level. This is the reason why most of the studies on the R&D spillovers are targeting either specific industries or "regional" areas.

Also in Italy, the analysis of the geographical distribution of R&D has been based, so far, on R&D and innovation data which were broken down at regional level (NUTS 2 level, according to the EU classification) as a lower level of aggregation was never been made available from the official R&D survey carried out by the Italian Statistical Institute.

In this paper we show some preliminary results of an exercise – carried out by Istat and the National Research Council – based on the matching between statistical micro-data from the Istat R&D survey and detailed administrative and official information at enterprise and institution level in order to break down the available information on the regional distribution of R&D activities to a much more detailed municipality level. These data, along with data on scientific publications and on patent applications to the European Patent Office, have been then regrouped by Local Labour System (Sistema Locale del Lavoro[2]) (LLS) for which also statistics on value added, employment and population are made available by Istat.

This effort is deemed to be particularly relevant as only a few countries – even in the European Union – make currently available R&D data at this geographical level and most of the literature, as well as public policies at the European and regional level, still consider the region as the unit of reference: this contribution allows one to shed some light into the regional "black box".

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1 As for the definition of "regional innovation systems" or similar concepts like "learning regions", "innovative milieu" or "industrial district". For a review, Doloreux and Parto, 2004.

2 A statistical unit, resulting from the aggregation of smaller geographical units, identified on the basis of the concentration of jobs with common features.

2. *Knowledge, regions and European policy*

The endogenous approach to local and regional development policy has become central over the last decade. It contends that regional development and economic growth should be driven by endogenous forces in terms of 'a highly educated workforce and knowledge and technologies developed in the region' (Todtling 2010). Innovation has also become a central concern of regional development policies due to the growing importance of knowledge economy and regional level for innovation support policy. The regional level is increasingly regarded as the key level to foster growth thanks to the presence of local knowledge spillovers, intra-regional labour mobility, and networks (Oecd 2011; D'Este, Guy, and Iammarino 2012). This process rests on the increasing awareness of the very mechanisms underlying the process of generation of knowledge and innovation. It has shown the prominence of interaction within localized context for learning (Lundvall and Johnson 1994). Thus co-location and proximity have been recognized as central for innovation generation and diffusion (Iammarino 2005; Iammarino and McCann 2006). The presence of increasing returns to scale which work at the local level emphasized by growth-related literature also points to the role of endogenous capabilities to enhance growth and productivity (Martin and Sunley 1998; Krugman 1991).

The EU main strategy on policies for cohesion, innovation, and growth is experiencing a deep rethinking in terms of strategies, instruments, and theoretical background. Regarding innovation policies, a paradigm shift in regional policy has occurred over the last decade in the EU, bringing innovation at the core of the regional agenda. This is grounded on a great wealth of research showing that the regional dimension is key for knowledge creation and diffusion, learning and innovation. The availability of Structural Funds, as the instrument for the EU cohesion policy, has provided regions substantial resources for innovation policy, reaching a share of innovation-related spending for the period 2007-2013 equal to approximately 25%.

The role of innovation in economic growth is expected to increase as other sources of growth decline in OECD countries. The challenge for national and regional governments is to identify the most appropriate policy levers for different stages of the innovation process — from knowledge generation and invention to innovation and commercialization — each of which can have a different spatial dimension. In this regard, the OECD and the EU (DG REGIO) are working to identify the most effective use of innovation policy funding for regions. Regional governments in the OECD are also determining their own innovation policies. On average, 64% of all capital expenditure of the public sector in OECD countries comes from regional or local governments. Comparable budget information at this level for investment and spending in innovation does not yet exist, but according to the recent OECD Survey on the Multi-level Governance of Science, Technology and Innovation, a wide range of measures to support innovation at regional level are being used, with significant budgets (Cavallaro, Sirilli, 2012).

A considerable share of resources was devoted to encourage innovation in all regions by the European Union Cohesion Policy. The investment in innovation for 2000-2006 was EUR 26 billion which corresponds to 11% of the previous EU envelope. The planned investments in innovation in 2007-2013 through cohesion policy are more than three times higher than in 2000-2006.

3. *Data processing*

R&D. The R&D expenditure data used in the analysis refers to year 2009. Data on firms at the municipality level have been calculated on the basis of the Istat R&D survey in which respondents provide information at the aggregate regional level (21 NUTS2 regions), matching the dataset with specific information from the official Istat business register, the fiscal records on the 2009 applications for R&D tax credits in Italy, and freely available information from institutional websites and electronic media.

Data on universities are based on the location of university departments; data available on public research institutions and private non-profit organizations have been broken down at municipality level through additional information requested to the institutions and on information available on the Internet (mainly from official websites).

Scientific publications. The statistics used in the paper have been compiled using the SCOPUS data base for the year 2010. Each publication was credited fractionally to each author and the fraction was assigned to the municipality on the basis of the affiliation of the author. Fractions pertaining to foreign authors and publications with more than one hundred authors have been excluded; for this reason the total number of publications is higher than the number used in the analysis.

Patents. Patent data have been compiled on the basis of the data on European patents collected by Francesco Lissoni and Michele Pezzoni for the "APE" project (Besten et al.) and referred to the sum of applications for the years from 2005 to 2008. It was felt appropriate to cover more than one year in order to have a sufficient number of observations for each LLS. For each patent the fractional number was calculated for each applicant and it was assigned to his/her address. As for publications, fractions pertaining to foreign applicants have been excluded. The breakdown by sector (enterprises, higher education, public institutions, private non profit institutions) has not been calculated for methodological reasons: the lack of information about the connection between the inventor and the likely relevant organization (in a non negligible number of cases university and public institutions researchers as well entrepreneurs apply for a patent on their own name instead of the organisation where the idea was developed - and this phenomenon is very difficult to measure) and the need to add a fifth category "other" to accommodate individual inventors.

Value added, population, employment. The data refer respectively to the years 2005, 2008, 2009 and have been downloaded from the Istat website on the Local Labour Systems.

4. *Knowledge creation at LLS level in Italy: a description*

As shown in Table 1, out of a total of the Italian 686 LLSs, a large majority of them, 78.3%, are involved in some inventive/innovative activity, i.e. R&D, scientific publications, patenting. However, the percentage of "knowledge intensive" LLSs, i.e those where these three activities are simultaneously present, is much lower: only 40.2%. Little more than half (55.0%) of the LLSs actually have public or private labs performing R&D, and 50.4% are the location of the authors of scientific publications: basically only half of the Italian LLSs can be associated with "knowledge creation" activities. Patenting shows a quite different pattern: the concentration of this phenomenon is significantly lower (71.3% of LLSs have at least one patent application), showing that inventions

for which an intellectual property right is applied for may not be the direct result of formal R&D activity (only in 50.9% of the LLSs both R&D performers and patent applicants can be found in the same years), but rather resulting from other technical activities like engineering, design or tooling-up, which are mainly based on the use of existing knowledge. Another interesting feature which emerges from the data is that only 41.5% of LLSs where R&D is carried out can be associated - for the same observation period – with the production of scientific publications; this may be explained by the fact that in less than half LLSs are based universities, public research institutions or private non profit organizations, which typically publish in journals their results, while in most of the LLSs R&D is carried out quite exclusively by business enterprises with a low propensity to share their knowledge in academic journals.

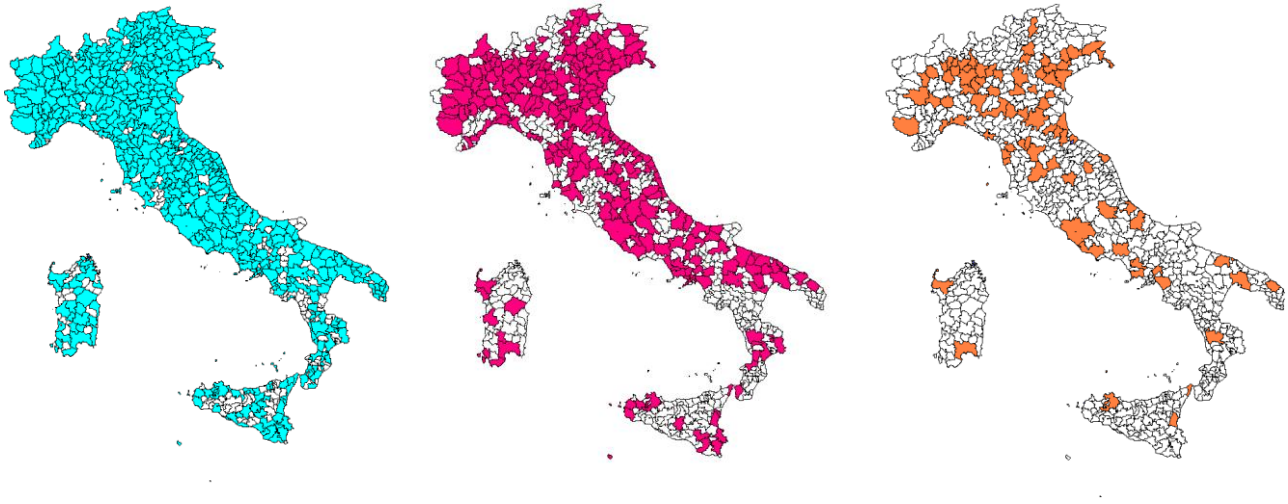
Table 1 - R&D, patents and publications in the Local Labour Systems (LLS) in Italy

LLSs in which the knoweldge activities are present	number	%
R&D	377	*55.0*
R&D (expenditure higher than 10 milion euro)	*137*	*20.0*
Patents	489	*71.3*
Patents (LLSs with more than 10 patents)	*170*	*24.8*
Publications	346	*50.4*
Publications (LLSs with more than 10 publications	*112*	*16.3*
R&D or patents or publications	537	*78.3*
Expenditure higher than 10 milion euro or more than 10 publications or more than 10 patents	*205*	*29.9*
R&D and patents and publications	276	*40.2*
Expenditure higher than 10 milion euro and more than 10 publications and more than 10 patents	*84*	*12.2*
R&D and patents	349	*50.9*
Expenditure higher than 10 milion euro and more than 10 patents	*112*	*16.3*
R&D and publications	285	*41.5*
Expenditure higher than 10 milion euro and more than 10 publications	*92*	*13.4*
Total LLSs	686	100.0

The skewed distribution of knowledge activities among Italian LLSs suggests that a more specific analysis could focus on the LLSs with more intensive activities of "knowledge creation". In Table 1 data in italics are calculated by adopting a set of given thresholds for the activities taken into consideration, i.e. LLSs where the expenditure on R&D is higher than 10 million euro and the number of publications and patents is higher than 10. By considering only this subset of "highly knowledge intensive" LLSs new, and more focused, evidence clearly emerges. The percentage of "knowledge intensive" LLSs decreases from 40.2% to 12.2%, that of LLSs with a R&D expenditure higher than 10 million euro from 55.0% to 20.0%, and that with more than 10 publications and patents decrease, respectively, from 50.4% to 16.3% and from 71.3% to 24.8%.

Figure 1 shows the distributions of the 537 LLSs where either R&D, or patents or publications are present (A); the 276 LLSs where R&D, patents and publications are jointly found (B); and the 84 "highly knowledge intensive" LLSs (C).

Figure 1 – Distribution of LLSs by "knowledge intensity"



(A) (B) (C)

The chart on the left hand suggests that almost all LLSs have some sort of knowledge activity; in the Southern regions, however, a significant number of "holes" are present. In general this kind of indicator is not sufficiently discriminating.

The chart in the middle provides a different picture: the LLSs where the three indicators are simultaneously present (276 over 686) are located mostly in the Centre-North and in the Adriatic belt.

The 84 LLSs which host a "significant" "quantity" of knowledge activities are much more scattered in the national territory and the majority of them is located in the North of the country. The others in most of the cases reside in the area of regional capitals.

In Table 2 some indicators of concentration of knowledge creation activities among LLSs are presented for two indicators, R&D expenditures and publications, by R&D performance sector.

The Gini concentration indexes are quite high for firms, public research and private non profit institutions, but it is lower for universities which are more evenly distributed across the country (even though they have Departments based in only 69 LLSs). Gini indexes for the first three categories range between 0.8 and 0.9, while it is around 0.65 for universities. Looking at the concentration from a different perspective, Table 2 displays that about the 10% of most active LLSs concentrate 80.5% of R&D expenditure and 88.7% of publications.

Table 2 - Concentration of knowledge in LLSs

	LLS		R&D expenditure	
	Gini index	number of LLSs	Percentage of LLSs	Percentage of R&D
R&D				
private enterprises	0.86	356	10.1	79.7
higher education	0.64	69	10.1	46.9
public agencies	0.89	132	10.6	84.3
private non profit	0.81	73	11	69.7
Total	0.87	377	10.1	80.5
Publications				
private enterprises	0.82	180	10	74.2
higher education	0.69	69	10.4	71.7
public agencies	0.89	320	10	86
private non profit	0.86	150	10	79.3
Total	0.91	337	10.1	88.7
Patents				
Total	0.81	489	10.2	71.4

Table 3 shows the absolute figures of the three indicators discussed above and the Gini concentration index of LLSs across regions. The evidence from the table can be summarized as follows:

- Most of the small regions (i.e. Friuli Venezia Giulia, Umbria, Marche, Abruzzi, Basilicata, Calabria, Sardinia, which account for 7.9% of the total R&D expenditure) display a low level of concentration for the three indicators;
- Also Veneto and Emilia Romagna, which are larger in terms of both area and population, show low levels of concentration of "knowledge creation" activities: this is an indicator that their "knowledge creation system", which is based on a mixed network of universities and enterprises, is spread over the regional territory,
- Piedmont, Lombardy, Tuscany and Lazio (the best performing regions) concentrate their knowledge potential in the regional capital or in the largest urban areas (including Turin, Milan, Firenze, Pisa, Siena and Rome).

Table 3 - Concentration or R&D, publications and patents among regions

	R&D			Pubblications			Patents		
	Expenditure	%	Gini index	Number	%	Gini index	Number	%	Gini index
Piemonte	2211957	11,5	0,88	3122	7,9	0,92	1504	10,4	0,74
Valle d'Aosta	28287	0,1	0,21	28	0,1	0,42	23	0,2	0,41
Lombardia	4051556	21,1	0,87	8001	20,1	0,92	4194	29,1	0,78
Trentino Alto Adige	436989	2,3	0,89	846	2,1	0,86	291	2,0	0,67
Veneto	1526597	8,0	0,74	3013	7,6	0,90	2070	14,4	0,63
Friuli Venezia Giulia	506613	2,6	0,71	1245	3,1	0,77	460	3,2	0,62
Liguria	590082	3,1	0,86	1318	3,3	0,87	302	2,1	0,72
Emilia Romgna	1848140	9,6	0,75	3742	9,4	0,85	2469	17,1	0,67
Toscana	1278239	6,7	0,87	3787	9,5	0,89	900	6,2	0,71
Umbria	283599	1,5	0,82	529	1,3	0,83	152	1,1	0,65
Marche	205000	1,1	0,69	626	1,6	0,79	408	2,8	0,57
Lazio	3010833	15,7	0,90	5667	14,3	0,91	783	5,4	0,88
Abruzzo	267372	1,4	0,73	542	1,4	0,75	149	1,0	0,66
Molise	32692	0,2	0,57	85	0,2	0,53	9	0,1	0,14
Campania	1222700	6,4	0,86	2482	6,2	0,88	291	2,0	0,80
Puglia	539020	2,8	0,81	1437	3,6	0,89	147	1,0	0,64
Basilicata	71419	0,4	0,63	151	0,4	0,74	20	0,1	0,49
Calabria	152253	0,8	0,76	653	1,6	0,82	47	0,3	0,58
Sicilia	713004	3,7	0,85	1873	4,7	0,87	138	1,0	0,73
Sardegna	217601	1,1	0,81	576	1,5	0,85	69	0,5	0,54
Italia	19193952	100	0,87	39724	100	0,91	14425	100	0,81

Table 4 and Figure 2 offer an additional view of the concentration of knowledge creation in Italy by focusing on the most active LLSs, i.e. those with a R&D expenditure higher than 10 million euro, and a number of patents and publications higher than 10 in the reference period.

In most highly "industrialized" regions of Northern Italy, almost two thirds of the LLSs are associated with at least 10 patent applications, while in Southern Italy only 5% of the LLSs have a comparable performance. In the regions of Central Italy the percentage of LLSs with more than 10 patents is, on average, lower than one third.

R&D expenditure shows a similar pattern, even though less polarized than for patents. It is worth mentioning that in Veneto and Emilia Romagna the percentage of LLSs with more the 10 million euro spent on R&D is quite high, around 50% (the national average is 24.8%).

The indicator of publications reflects mostly the fact that the scientific infrastructure of the country, which is basically made of universities and public research institutions, is present in a rather large number of LLSs in Northern-Central regions (about one fourth) and in very few LLSs in the South (less than one in ten).

Figure 2 – LLSs where the value of R&D, patents and publication is higher than the given threshold

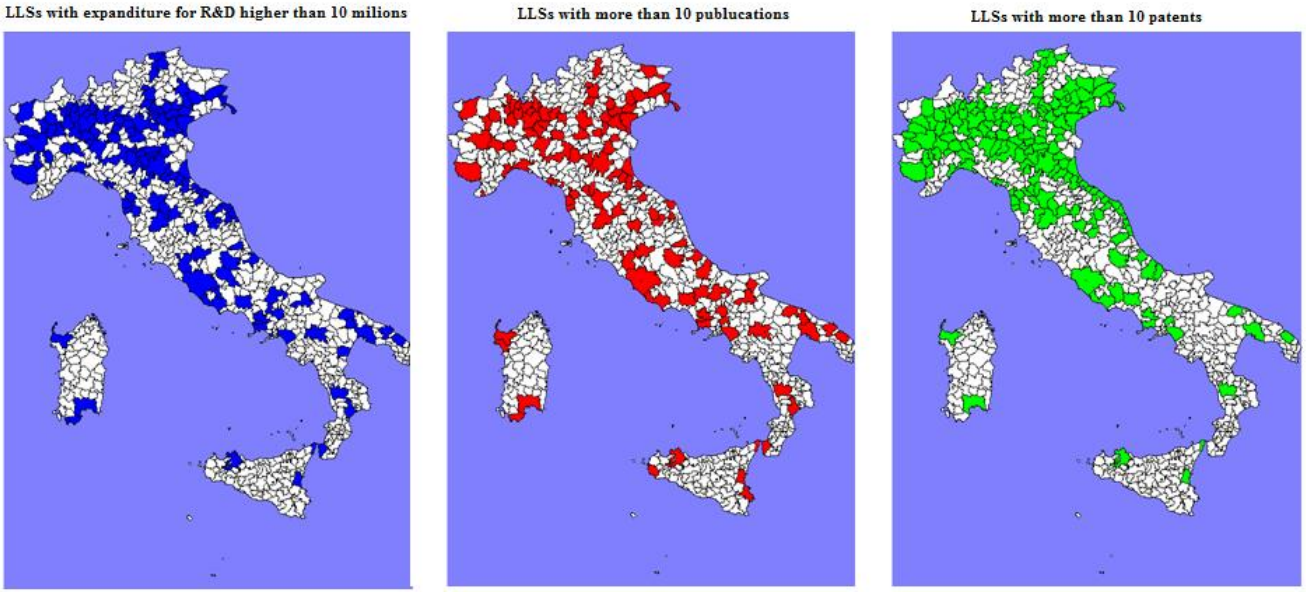


Table 4 - SLLs in which R&D, patents and publications are present beyound a given threshold

Region	LLSs	LLSs with an R&D expenditure higher than 10 million euro		LLSs with more than 10 publications		LLSs with more than 10 patents	
	number	number	%	number	%	number	%
Piemonte	37	14	37.8	9	24.3	23	62.2
Valle d'Aosta	3	1	33.3	1	33.3	1	33.3
Lombardia	58	22	37.9	15	25.9	30	51.7
Trentino Alto Adige	33	6	18.2	4	12.1	8	24.2
Veneto	34	15	44.1	11	32.4	21	61.8
Friuli Venezia Giulia	11	4	36.4	5	45.5	7	63.6
Liguria	16	2	12.5	4	25.0	4	25.0
Emilia Romagna	41	19	46.3	11	26.8	25	61.0
Toscana	53	8	15.1	9	17.0	15	28.3
Umbria	17	2	11.8	2	11.8	4	23.5
Marche	33	9	27.3	5	15.2	11	33.3
Lazio	25	5	20.0	4	16.0	4	16.0
Abruzzo	19	4	21.1	4	21.1	4	21.1
Molise	9	1	11.1	2	22.2	0	0.0
Campania	54	8	14.8	6	11.1	4	7.4
Puglia	44	6	13.6	7	15.9	3	6.8
Basilicata	19	2	10.5	1	5.3	0	0.0
Calabria	58	3	5.2	3	5.2	1	1.7
Sicilia	77	3	3.9	5	6.5	3	3.9
Sardegna	45	3	6.7	4	8.9	2	4.4
Totale	686	137	20.0	112	16.3	170	24.8

The availability of an original dataset, based on a detailed information on the geographical distribution of "knowledge creation" activities in Italy, allows one to produce some rankings which reflect the patterns of concentration of these activities already described above (Table 5 and Table 6). The amount of resources devoted to knowledge activities (R&D, publications and patents, Table 5) is concentrated in the LLSs where the largest Italian cities are located (the ranking is quite similar across the three indicators, Table 5).

The intensity ratios (Table 6) show a completely different picture. The LLSs where large cities are located disappear while LLSs with small towns like Bassano del Grappa, Fabriano and Vipiteno are constantly among the top 15 LLSs. Furthermore there is a scant presence of LLSs of Southern Italy, even for the indexes based on publications.

Table 5 - The most knowledge intensive LLSs

LLS denomination	R&D expenditure (million euro)	percentage of the national total	LLS denomination	Publications (number)	percentage of the national total	LLS denomination	Patents (number)	percentage of the national total
Roma	2791	14.5	**Milano**	5639	14.2	**Milano**	1693	11.7
Milano	2454	12.8	**Roma**	5409	13.7	**Torino**	805	5.6
Torino	1737	9.1	**Torino**	2674	6.8	**Bologna**	754	5.2
Napoli	903	4.7	**Bologna**	1974	5.0	**Roma**	658	4.6
Bologna	636	3.3	**Padova**	1878	4.7	**Padova**	333	2.3
Firenze	528	2.8	Napoli	1782	4.5	Bergamo	319	2.2
Genova	510	2.7	Pisa	1538	3.9	Como	223	1.5
Padova	420	2.2	**Firenze**	1529	3.9	Vicenze	222	1.5
Pisa	362	1.9	**Genova**	1205	3.0	Brescia	212	1.5
Sesto Calende	346	1.8	Bari	837	2.1	Verona	210	1.5
Catania	341	1.8	Trieste	780	2.0	Modena	209	1.4
Modena	294	1.5	Pavia	753	1.9	**Genova**	196	1.4
Bari	290	1.5	Catania	722	1.8	**Firenze**	189	1.3
Trento	285	1.5	Palermo	666	1.7	Parma	184	1.3
Verona	264	1.4	Trento	616	1.6	Seregno	179	1.2

Table 6 - The most knowledge intensive LLSs

R&D expenditure/population		R&D expenditure/Value added		Publications/population		Publications/R&D expenditure of public and non profit institutions		Patents/population		Patents/Value added	
Denomination of the LLS	euro per capita	Denomination of the LLS	1/1,000	Denomination of the LLS	number/ 1,000 population	Denomination of the LLS	number/ million euro	Denomination of the LLS	patents/ 1,000 population	Denomination of the LLS	number/ million euro
Sesto Calende	2311	Sesto Calende	121	Pisa	8,5	Castelfranco Veneto	2237	Modigliana	1,4	Modigliana	67
Pisa	2008	Cento	68	Siena	4,7	Imola	2202	Fabriano	1,1	Sesto Calende	50
Siena	1910	Pula	34	San Severino Marche	4,3	Pordenone	1274	Siena	1,0	Montebelluna	45
Trento	1467	Ivrea	34	Pavia	4,0	Ivrea	1238	Vipiteno	1,0	Vipiteno	44
Cento	1209	Siena	33	Trieste	3,3	Isernia	769	Bologna	1,0	Fabriano	43
Trieste	1068	Trento	29	Trento	3,2	Gorizia	597	Montebelluna	0,9	Mogliano	40
Urbino	1067	Torino	28	Padova	3,0	Cesena	270	Sesto Calende	0,9	Carpi	40
L'Aquila	1039	L'Aquila	27	Bologna	2,6	Matera	267	Carpi	0,9	Gaggio Montano	40
Mezzolombardo	1014	*	-	Perugia	2,2	Bassano del Grappa	220	Ferrara	0,9	Piazza Brembana	39
Cassino	986	*	-	Firenze	2,2	Legnago	212	Schio	0,9	Schio	39
Torino	974	Vipiteno	26	Urbino	2,1	Fiera di Primier	178	Imola	0,9	Siena	38
Pavia	931	Modena	24	Cosenza	2,0	Siracusa	172	Bassano del Grappa	0,8	Bassano del Grappa	36
San Severino Marche	928	Pisa	22	Ferrara	2,0	Sesto Calende	151	Vicenza	0,7	Filottrano	35
Modena	884	Fabriano	21	L'Aquila	2,0	Savona	150	Mogliano	0,7	Ferrara	35
Pula	872	Pontedera	20	Mezzolombardo	1,8	San Remo	131	Sassuolo	0,7	Pratovecchio	34

* Two LLSs (and their relevant information) can not be disclosed because of confidentiality constraints (less than 3 observations)

5. ***The relationship among the "knowledge activities" of LLSs***

Beyond the analysis on the level of concentration of "knowledge activities", an attempt has been made to identify to what extent they are linked each other at LLS level. This approach is aimed at identifying some evidence of phenomena like the "cross-fertilization" of public-private research activities, as well as the mission oriented orientation of public-private research to a scientific outcome (publications), rather than to a technological outcome (patents).

On the input side, as shown in Table 7, the expenditure for R&D carried out by the four institutional sectors have a very level of correlation among them. The highest association at LLS level can be found between business R&D (BES) (0.81) and university R&D (Higher Education Sector, HES), where the link between business R&D and public institutions' R&D (GOV) is less strong (0.57), albeit positive

Table 7 - Coefficients of correlation among intra-mural R&D expenditure by sector at LLS level

Pearson product-moment correlation coefficients (Obs. 537)
Prob > |r| with H0: Rho=0

	BES R&D	GOV R&D	PNP R&D	HES R&D
BES R&D	1,0000	0,57349 <,0001	0,70237 <,0001	0,81466 <,0001
GOV R&D		1,0000	0,38359 <,0001	0,72731 <,0001
PNP R&D			1,0000	0,57924 <,0001
HES R&D				1,0000

Even the relationship between university R&D and public R&D is not so strong as that of university and business research. Also for the non profit sector (PNP, mainly including large private hospitals), the opportunities for research – at least in terms of localization – are higher where also a relevant business R&D activity can be found . Moreover, the investment on R&D is highly correlated among sectors and is even difficult to identify some sectoral "specialization" at LLS level.

As the relationship between input and output factors in the knowledge creation process in Italian LLSs, a similar picture can be shown with all the knowledge-related activities highly correlated among them. Differences among sectors for such activities are lower than expected (Table 8), as – for instance – business R&D is strongly linked to the level of scientific publications in all sectors, as well as to the overall patenting performance. In this respect, the role of business R&D is largely prevailing on that of other sectors. In a context of a positive correlation among all the variables taken into consideration, the association between the patenting performance and business R&D is

not surprisingly twice higher than with public R&D. But the business R&D is even influencing the level of scientific publications in the public sector more than "public" R&D.

Table 8 - Coefficients of correlation between intra-mural R&D expenditure by sectors and scientific publications (by sector, PUB) and patents (all sectors, PAT), at LLS level.

Pearson product-moment correlation coefficients (Obs. 537)

Prob > |r| with H0: Rho=0

	PUB BES	PUB GOV	PUB PNP	PUB HES	PAT
BES R&D	0,90319	0,88166	0,86187	0,88039	0,90025
	<.0001	<.0001	<.0001	<.0001	<.0001
GOV R&D	0,69897	0,80772	0,61315	0,7127	0,44823
	<.0001	<.0001	<.0001	<.0001	<.0001
PNP R&D	0,75589	0,66793	0,84028	0,66131	0,72223
	<.0001	<.0001	<.0001	<.0001	<.0001
HES R&D	0,87746	0,94401	0,78534	0,97126	0,75468
	<.0001	<.0001	<.0001	<.0001	<.0001

Not a secondary role is indeed played by the university R&D, strongly correlated to all the output factors – by either public or private sectors – including patents.

As a general comment it has to be underscored that small differences in the distribution at LLS level of the variables calculated for the analysis reduces in fact the potential of this dataset to be used for profiling of the knowledge creation activity of Italian LLSs.

6. *Sectoral R&D specialization in the Italian LLSs*

In order to identify the sectoral specialization of the Italian LLSs as to the creation of new knowledge, the 537 LLS with some evidence of at least one scientific and technological activity have been analyzed in order to identify their key features and – by means of a clustering process – to classifying them in terms of sectoral specialization and scientific-technological performance. Several attempts have been unsuccessful– beyond the dichotomy between the LLS where the S&T activities are intensive and those where are irrelevant – any other difference is quite blurring as a result of the high level of correlation among the observed variables.

A meaningful differentiation among the LLS behaviors in terms of knowledge creation, has been observed by processing the a dataset including as variables only the percentage of R&D expenditure performed by each single institutional sector. By focusing the analysis on 377 observations related to the R&D performing LLSs, four groups of LLS have been identified with a prevalent specialization in the R&D performance of a specific institutional sector. This analysis has been based on a hierarchical average-linked clustering model.

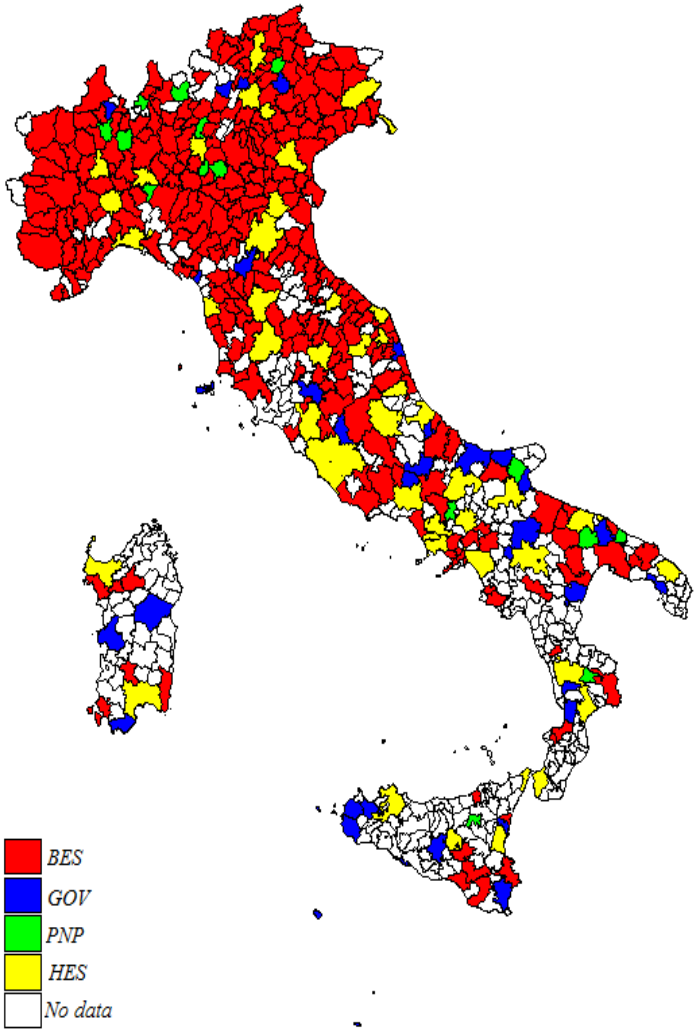
Table 9 - Average scores of the four clusters of LLSs

Data on 377 observations (LLS)

		Variables used in the analysis				Additional variables	
	Obs.	BES R&D / Total R&D	GOV R&D / Total R&D	PNP R&D / Total R&D	HES R&D / Total R&D	Patents / 1000 pop.	Scient. Publications / 1000 pop.
Cluster 1 (LLS specialised in PNP R&D)	15	0,19	0,01	0,8	-	0,15	0,15
Cluster 2 (LLS specialised in HES R&D)	46	0,22	0,1	0,02	0,66	0,22	1,56
Cluster 3 (LLS specialised in GOV R&D)	33	0,15	0,83	0,02	-	0,08	0,18
Cluster 4 (LLS specialised in BES R&D)	283	0,96	0,02	-	0,02	0,23	0,09
Total	377	0,77	0,1	0,04	0,09	0,21	0,28

From Table 9 the relative size of the four clusters can be observed. The cluster of LLSs specialized in BES R&D is by far the largest (75% of the observed population). It includes LLSs where, on average, BES R&D accounts for 96% of the total R&D and GOV R&D, as well as HES R&D play only a minor role. The LLS where HES is prevalent (66% of the total R&D expenditure, on average, in the observed units) are only 46 and are those with the best performances in terms of output as they show, on average, the highest scores in patenting and publications (for these LLSs also a contribution by business enterprises in terms of R&D, 22%, can be observed). Only 33 LLS are featuring a key role of public R&D (83% of total R&D, on average) and 15 LLS are specialized in non profit R&D (80%).

Figure 3 – Clusters of knowledge creation and diffusion



In Figure 3 the distribution of these clusters on the national territory is shown. LLSs specialized in BES R&D (red color) can be mainly localized in Northern-Central Italy, overlapping the areas with a highest concentration of industrial activities in Italy (Piedmont, Lombardy, Veneto, Emilia). In the South of the country, these LLSs are usually relying on a few of large factories (or even just one) to perform high in business R&D. It is worth to point out that LLSs can be identified as "specialized in business R&D" also in those cases where other research institutions – much more widely scattered on the national territory than business enterprises – simply do not exist. On the other hand, the largest – and most S&T advanced – urban areas in Italy are included in the cluster of LLS specialized in university R&D (yellow color). In areas where both private and public R&D activities are relevant, the R&D performed by university can play a key role to "catalyse" the potential for knowledge creation and improve the performance of the S&T system. The LLSs where public R&D (blue color) has a key role can be found all over Italy. Finally, a geographical polarization can be observed for the LLSs where non profit R&D is prevalent. In fact, these areas

can be found either in Northern or Southern Italy, where some large institutions (often, large hospitals) are based.

7. *Conclusions*

It seems possible to argue that even a descriptive analysis of "knowledge creation" activities at "sub-regional" level helps to understand more in detail what is the geographical structure of research and innovation in Italy.

Knowledge activities in Italian LLSs (R&D, patents, publications) are quite spread over the Italian territory but, at the same time, they are also heavily concentrated. A large majority of LLSs (78.3%) shows some evidence of "knowledge activities" but only about half of them accommodate public or private R&D performers or authors of scientific publications. The concentration is even more evident if a threshold is used in order to identify "highly knowledge intensive" LLSs: those with a R&D expenditure higher than 10 million euro and with more than 10 patents and publications in the observed period account for 12.2% of the total. (Of course, different threshold values could be used to identify larger or smaller sub-populations).

Gini concentration indexes show a very high level of polarisation of knowledge activities among LLSs, at least in three out of four performing sectors (enterprises, public research institutions and private non profit institutions). The concentration is however lower in the higher education sector.

Such high levels of concentration of the observed activities, beyond preventing to define any clear taxonomy of the Italian LLSs in terms of "knowledge creation", emphasize the role of the highly industrialised regions, as well as of the largest urban areas. In this perspective it can be pointed out that at least the intensity ratios (i.e. R&D/value added, R&D/population, publications/population, patents/value added) offer a quite different picture: large cities are over-performed by small and medium towns as "knowledge intensive" areas. In principle, as far as knowledge creation is concerned, concentration and overall performance may not match with "intensity" or "specialization".

In a wider geographical perspective, data presented in the first part of this paper largely confirm the traditional dichotomy between Northern and Southern Italy: Northern regions host an highest percentage of the national R&D expenditure and have almost a monopoly for patents.

Data at LLSs level allow us to point out that there are no major differences in the geographical distribution of research expenditure and output if we still focus on large urban areas: considering the LLSs with the highest level of R&D expenditure or publications, we can even find a large presence of Southern cities, such as Naples or Bari.

The main difference is about the "less knowledge active" LLSs: in Southern Italy, for instance, there is a significant gap of research activities between the urban areas and the territories less intensively urbanized and industrialised. On the other hand, in the Northern regions, even small LLSs have some evidence of R&D expenditure or patents (as these activities are usually carried out by the private sector).

Of course, not all the Northern regions displays the same features. Piedmont and Lombardy – as expected - concentrate their knowledge potential around their large urban areas (which are also

constantly expanding as it is even difficult to identify the boundaries between them), while Veneto and Emilia Romagna have a more even diffusion of R&D activities. These differences are strictly connected with the structure of university network and productive activities in these regions: Veneto and Emilia Romagna have a high number of universities and there also is a large number of small or medium enterprises struggling to innovate at their best in order to preserve their market share.

While for Veneto and Emilia Romagna we could assume that a "Regional Innovation System" can be identified, for Piedmont and Lombardy we can just observe a "Local Innovation System" has emerged, by attracting and stoking up some peripheral small systems.

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