

REGIONE  
TOSCANA



**THE REGIONAL RESEARCH  
AND INNOVATION SYSTEM**



# **THE REGIONAL RESEARCH AND INNOVATION SYSTEM**

Edited by:  
Region of Tuscany - Regional Government  
Directorate General Presidency  
Directorate General for Regional Competitiveness and Capacity Building  
Area of Research Coordination  
EU Liaison Office



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## **Tuscany: centuries devoted to the future of humankind**

A crossroads of peoples and knowledge, Tuscany has been proposing art, genius, science, dialogue and invention to the world for millennia. Not just the art of Michelangelo, the genius of Leonardo, the politics of Machiavelli, the science of Galileo, the Nobel Prizes of Carducci, Fermi and Rubbia, but a unique, sparkling mix of artists, scientists, thinkers and patrons.

Four universities in Florence, Pisa and Siena; post-graduate and higher education schools such as the Scuola Superiore Sant'Anna and the Scuola Normale Superiore in Pisa, the Institute of Human Sciences in Florence and the IMT Institute for Advanced Studies in Lucca; national research institutes such as the National Research Council (CNR), the National Institute of Nuclear Physics (INFN), the National Institute of Astrophysics (INAF) and the National Institute of Geophysics and Volcanology (INGV).

A prestigious fabric of universities, schools, academies and research centres that, together with libraries, museums and cultural centres, are the most important heritage of the modern Tuscan age.

A system of knowledge whose roots go back a long way: of the 52 universities in the world founded before 1500, no less than 19 are Italian, mainly concentrated in Emilia Romagna (Bologna is the oldest university) and Tuscany. Pisa University was founded in 1343, consolidating university courses already begun in the 11th century; Florence University (Studium) was established in 1321 and moved to Pisa in 1473, only returning to Florence upon the unification of Italy in the 19th century. As an emanation of Bologna, a Studium was founded in Arezzo in 1215, later to be absorbed by Siena when its own Studium was established in 1240. The Scuola Normale Superiore in Pisa was founded in 1810, while the Scuola Superiore Sant'Anna dates from a century later, in 1908.

Few other regions feature such a high concentration of institutions of knowledge and know-how operating for such a long, uninterrupted period. There is no denying its reflection on Tuscan society and civilisation: suffice it to think that Tuscany (during the period of the Grand Duchy) was the first state in the world, on 30 November 1786, to abolish torture and the death penalty.

A system of knowledge strongly rooted in the past but with a definite orientation towards the future. The Tuscan research and innovation system, in which universities, public and private research centres, enterprises and public institutions take part, stands out thanks to its clear vision of the future scenario and shared goals.

The awareness that research has important consequences, not just on the cutting edge of business and the labour market, but also and above all on the environmental and social sustainability of growth, as well as on the well-being and quality of life of present citizens and future generations, has prompted the institutions and the research institutes to strive towards a shared, long-term action programme.



## Tuscany: general characteristics

Tuscany is widely known for its exceptional cultural, artistic and landscape heritage, the fruit of investments in culture and research built up over centuries. Less well known, probably, are its characteristics as a regional entity, its economy and its capacity for production and innovation. Here is a summary of the data.

### BOX – THE TUSCAN PRODUCTION SYSTEM

Tuscany covers a surface area of 23,000 km<sup>2</sup> and counts around 3.7 million inhabitants, mainly resident in small and medium-sized towns. 70% of the population and three-quarters of non-agricultural jobs are concentrated in just 30% of the territory, in small towns and clusters of small and medium-sized enterprises.

In production terms, a GDP with an absolute value of over 106.000 million euros [Source: Eurostat, 2011] rates Tuscany as the 25th most important region in the EU27; also in terms of GDP per capita (28,700 Euros) it is placed clearly above the EU27 average (25,000 Euros) and just below that of the EU15 (29,000 Euros).

In terms of employment, the region shares the difficulties currently being experienced in Europe: the employment rate in Tuscany recently fell to 62.5% (EU 27 64.1%; EU15 65.3%). The difficulty for the region's small and medium-sized enterprises to compete has converted into growing levels of unemployment, especially among women and young people: the rate of unemployment among young people in Tuscany amounts to 23.1%, a value which, albeit much lower than the Italian average (27.8%), is nevertheless higher than the European mean (EU15 20.3%; EU27 20.9%).

The Tuscan production system, emphasizing a feature shared by many European countries, shows a high level of fragmentation: 84.9% of the region's companies have less than 10 employees (83.8% EU27) and 9.8% less than 20 (9.2% EU27). Large companies with over 250 employees, which number just 189, nevertheless account for 12.8% of the region's employees.

As far as sector specialisation is concerned, the Tuscan system is still heavily based on manufacturing: with over 325 thousand workers, that is over 27.2% of the overall workforce (counting around 1,200 thousand), manufacturing is the main engine driving the regional economy.

Commerce and the hotel and restaurant sector, given Tuscany's strong tourist attraction, employ 245,000 and 95,000 workers respectively; in the most evolved part of the tertiary sector, financial and insurance brokering activities and business services employ another 230,000 workers.

In the manufacturing sphere, characterised by a large proportion of small and medium-sized enterprises, the most important production activities are linked to traditional sectors: food and agriculture, goldsmithery, and, above all, fashion – where the presence of numerous global brands (Gucci, Prada, Ferragamo, Celine, Dior, etc.) – makes the Tuscan cluster (with over 102,000 employees) an international hub of luxury and creativity.

Alongside these traditional production sectors there are significant presences in the mechanics, leisure boating, automotive and railway transport areas. Among the most high-tech sectors: production linked to ICT, optoelectronics (photonics), medical devices, pharmaceuticals and biotechnologies.

The industrial profile just outlined is based on traditional activities, which are often craft activities with little attitude towards technological innovation; however, they are highly innovative in terms of design, style and creativity. Alongside these are production units operating in more modern and technological sectors which often entertain important partnerships with local and global research centres.

## **The regional research system**

On the whole, Tuscany invests relatively little in research and development (1.22% of its GDP), less than the European average (EU27 2.01%; EU15 2.1%).

However, if we go from the overall figure to consider the public research system alone, the assessment changes radically and Tuscany, with an absolute expenditure of € 711 million, ranks as the 30th region in the EU27 for (public) expenditure on research and development. In relative terms, the public component of regional expenditure on research and development accounts for 0.59% of the GDP, a much higher value than the Italian average, albeit still below the European average (public expenditure on R&D in the EU27 accounts for 0.66% of the GDP and in the EU15 for 0.67%).

It is evident that the lower relative investment in research in Tuscany depends totally on the private component of the system which, given the small size of the companies and the great specialisation in the traditional sectors described above, suffers from a lack of inclination to invest in research and development (0.42% against 0.65% at the national level, 1.2% in the EU27 and 1.26% in the EU15).

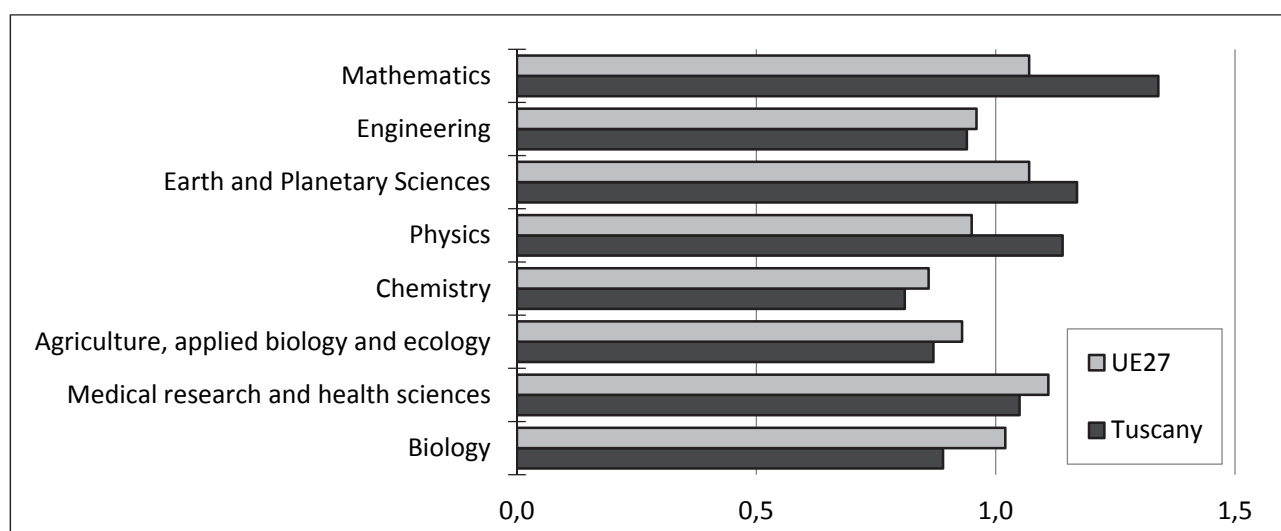
Consequently, Tuscan scientific production is coherent with the characteristics of a research system in which the public component appears to play the greater role: against a not-yet-competitive number of registered patents we find a substantial production of scientific publications. 1.12% of European scientific publications come from Tuscany, placing it in 16th place in the EU27 regional classification for scientific density, with 163 publications per capita (compared to a European average of 170). Moreover, Tuscany ranks among the top 15 European regions in terms of the number of publications in numerous disciplines of great interest for the future of European research, such as mathematics, earth and universe sciences, physics, engineering sciences, applied biology and ecology, and medical and chemical research (see table 1 and graph 1).

Table 1 Specialisation index and publication rank per scientific discipline in Tuscany

Scientific disciplines	Rank (within the first 25 EU27 regions)	Specialization index
Mathematics	3°	1,34
Earth and Planetary Sciences	8°	1,17
Physics	9°	1,14
Engineering	12°	0,94
Agriculture, applied Biology and ecology	12°	0,87
Medical research and health sciences	13°	1,05
Chemistry	13°	0,81
Biology	22°	0,89

\* normalised on the world average value

Graph 1 Comparison of the specialisation index per scientific discipline between Tuscany and the EU27



Source: OST 2010

The excellent results in terms of publications derive from the significant number of personnel allotted to research activities: the research sector employs 22,588 people in Tuscany (14,773 if considered as full-time equivalent units) (source Eurostat 2009).

In Tuscany the percentage of public sector researchers out of the active population is higher than the European average, compared to both the EU27 and EU15 (see table 3); this fact therefore reflects the proportion already observed between public and private expenditure on research and development and shows the strength of the Tuscan public research system.

If we go from the total number of research personnel to consider researchers only (net of technicians and technologists), the figure falls because a large part of public research in Tuscany is carried out by university institutes and, as a consequence,

lecturers counted as research personnel are only considered in part since they do not exclusively carry out research activities but are also engaged in teaching.

*Table 2 Percentage of research personnel and researchers in Tuscany out of the active population*

Full time equivalent data	Public Sector	
	R&D personnel	Researchers
<b>Tuscany</b>	<b>0,57</b>	<b>0,34</b>
EU27	0,49	0,35
EU15	0,53	0,37

Source: Eurostat 2009

## University and research institutes in Tuscany

Tuscany hosts numerous public research institutes and universities. There are three general universities: in Florence, Pisa and Siena; in addition there is a university for foreigners in Siena, specialised in Italian language and culture.

Alongside the state universities are two schools of higher education that also carry out undergraduate education activities, the Scuola Normale Superiore and Scuola Superiore Sant'Anna in Pisa, and two post-graduate institutes, the IMT Institute for Advanced Studies in Lucca and the Institute of Human Sciences in Florence.

Alongside the university system, four of the biggest national research institutions have institutes and operating bases in Tuscany: the National Institute of Nuclear Physics (INFN), with sections in Florence and Pisa, the National Institute of Astrophysics (INAF) based in Florence, the National Institute of Geophysics and Volcanology (INGV), located in Pisa, and the National Research Council (CNR), mainly set out around two principal research areas, located in Florence and Pisa. Numerous research institutes operate within the two CNR areas (6 in Florence and 7 in Pisa), as well as many sections of institutes based outside the region (4 in Florence and 7 in Pisa); moreover, external to the CNR area, an additional four CNR Institutes operate in the Florence territory; further two sections of the CNR operate in Siena and Massa Carrara. To list some of the most important CNR institutes operating in Tuscany: the Institute of Clinical Physiology (IFC), the Institute of Information Sciences and Technology, the Institute of Informatics and Telematics (IIT), the “Nello Carrara” Institute of Applied Physics (IFAC), the Institute of Biometeorology (IBIMET), the National Institute of Optics (INO).

Tuscan research centres and universities are members of numerous and important international collaboration networks. Each institute, department or single group

develops different types of relationships with international poles of excellence, which is difficult to summarise in just a few pages<sup>1</sup>. Evidence on this involvement in European research networks is provided by the number of scientific publications which researchers from Tuscan universities and research centres realise jointly with other members of these European research networks: Tuscany represents 2.84% of total European co-publications of the London region, 2.95% of those of the Ile-de-France region, 2.90% of the Madrid region, 3.03% of that of Helsinki, 3.75% of that of Rhône-Alpes, 4.35% of that of Oxford, 5.32% of the Catalogna region and 5.06% of the Karlsruhe region (source: OST, 2010).

Alongside these main research institutions there are also top infrastructures resulting from partnerships between some of the research institutes and universities quoted above (to which the research personnel are generally connected) and other international research entities. Among these it is obligatory to name:

- the European Laboratory for Non-Linear Spectroscopy (LENS), established twenty years ago as a Florence University centre of excellence and since then the European reference point for research through light waves. Based on a fundamental multidisciplinary approach, its work finds applications from atomic physics to photonics, biophysics to chemistry;
- the Florence University Magnetic Resonance Centre (CERM), leading light in international research in the field of nuclear magnetic resonance (NMR) applied to life sciences, which has some special high-field spectrometers equipped with cryoprobes at its disposal. CERM is one of the institutions behind the foundation of the INSTRUMENT European research infrastructure that links 20 centres of excellence in the field of magnetic resonance and a further 160 research institutions around the world such as the Max-Planck Institute in Germany, CNRS in France and the Weizmann Institute in Israel.
- the European Gravitational Observatory (EGO), a French and Italian consortium (INFN-CNRS) based in Cascina (Pisa) where is installed the big interferometric antenna VIRGO, an ultra sensitive detector for studying gravitational waves.

As well as these European research infrastructures, which bear the status of European Research Infrastructure Consortium (ERIC), we can point out at least two other important research laboratories at the international level: the Nuclear

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<sup>1</sup> For instance, IFAC performs research and develops new technology in the biophotonic sectors (taking part in the European platform Photonics21, as well as in Eranet+), the environment and space sectors (with the participation in various ESA projects), together with the cultural goods sector as a leader in the laser techniques in CHARISMA, the unique European research infrastructure existing in this sector in Europe.

Techniques for the Cultural Heritage Laboratory (LABEC), based at INFN in Florence, and the National Enterprise for NanoScience and NanoTechnology (NEST), at the Scuola Normale Superiore.

In addition, two centres of the Italian Institute of Technology are active in Tuscany: the Centre for Micro-Biorobotics at the Scuola Superiore Sant'Anna and the Centre for Nanotechnology Innovation that operates within NEST at the Scuola Normale Superiore.

Besides this, the Galileo Galilei Institute (GGI), international centre of excellence in theoretical physics, created and financed by the INFN in partnership with the University of Florence, attracts the best international experts in the field.

Lastly, in the sphere of socio-economic sciences and historical studies we can point out the European University Institute (EUI), a research institution whose roots lie in the European Union construction process.

*Table 3 Tuscan university and research institute researchers as at 2012*

<b>Universities and research institutes</b>	<b>Full and associate professors</b>	<b>Researchers</b>	<b>Fixed-term and post doc researchers</b>	<b>TOTAL</b>
University of Florence	1.190	629	904	2.723
University of Pisa	968	626	298	1.892
University of Siena	494	366	94	954
University for foreigners of Siena	17	24	4	45
Scuola Normale Superiore	28	53	78	159
Scuola Superiore Sant'Anna	54	19	261	334
IMT Lucca	7	1	23	31
Institute of Human Sciences (SUM)	8	0	0	8
<b>University total</b>	<b>2.766</b>	<b>1.718</b>	<b>1.662</b>	<b>6.146</b>
CNR (*)	0	723	321	1044
INFN (*)	0	87	29	116
INAF	0	54	9	63
INGV	0	28	4	32
<b>Research Institutes Total</b>	<b>0</b>	<b>892</b>	<b>363</b>	<b>1.255</b>
<b>GRAND TOTAL</b>	<b>2.766</b>	<b>2.610</b>	<b>2.025</b>	<b>7.401</b>

(\*) The CNR figure refers to researchers and technologists

Source: MIUR 2012

In terms of overall personnel, the three general universities account for over 80% of the total; nevertheless, in terms of research capacity, the universities probably bear less weight since we need to consider that the universities also carry out higher education activities. In the Universities part of the research personnel's time is

therefore devoted to lecturing and, considering the need to guarantee a good level of services to students, a large part of the staff, not involved in research activities, work in administration; the research institutes whose main mission is not to provide education, instead prevalently count technicians and technologists.

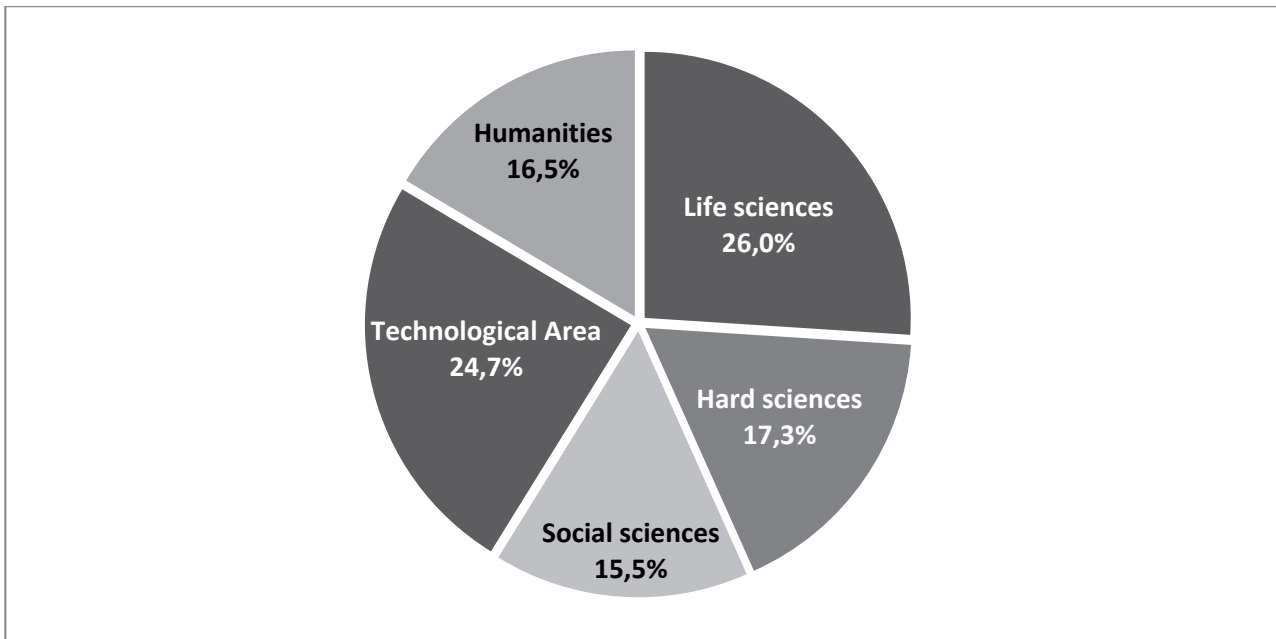
As far as the composition of the personnel that only carry out research activities in universities are concerned, table 4 and graph 2 count lecturers, researchers, technologists and post-doctoral researchers according to the scientific discipline sector that they belong to, which is then traced back to the five disciplinary areas singled out by the Ministry of Education, University and Research (MIUR). What results is quite a varied and not excessively unbalanced composition: after the technological area, which employs one quarter of Tuscan researchers, comes the biomedical area, followed by the scientific area and lastly the human sciences and social sciences areas which together account for almost one third of Tuscan researchers.

*Table 4 Research personnel in Tuscan universities by disciplinary area as at 31/12/2011*

<b>Macro Area</b>	<b>Scientific disciplinary area</b>	<b>R&amp;D Personnel</b>	<b>%</b>
Life sciences	Biology	567	9,2
	Health sciences	1.030	16,8
Hard Sciences	Chemistry	374	6,1
	Earth and Planetary Sciences	164	2,7
	Physics	268	4,4
	Mathematics	257	4,2
Social Sciences	Economics and statistics	423	6,9
	Law	382	6,2
	Political Sciences, sociology	149	2,4
Technological Area	Civil engineering and architecture	312	5,1
	Industrial Engineering, computer science, IT	828	13,4
	Agricultural and animal sciences and technologies	378	6,1
Humanities	Ancient history, philology and literature, history of arts	581	9,5
	History, philosophy, psychology and science of education	435	7,1
<b>TOTAL</b>		<b>6.146</b>	<b>100</b>

Source: MIUR 2011

Graph 2 Composition of researchers in Tuscan universities by macro disciplinary area as at 31/12/2011



Source: MIUR 2012

## **The competitive capacities of the regional research system: participation in European and Italian calls for proposals**

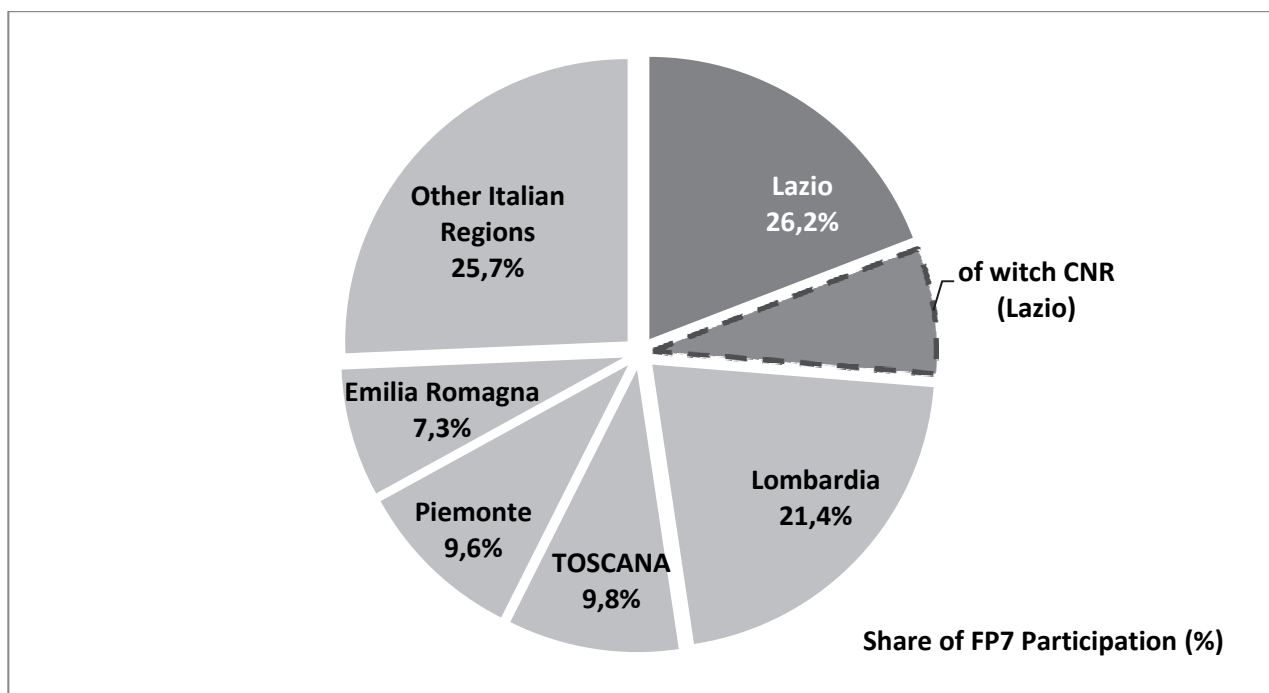
The 7th Framework Programme is coming to a close and it is possible to begin to trace a general picture of the European Member States and regions' participation.

From the beginning of the programme to date (March 2012), Italian research centres have acquired funding for the 7th Framework Programme (FP7) amounting to 2,316.20 MEUR, with 7,899 projects funded, of which 1,332 as coordinators.

Despite these significant results, Italian participation is still lower than expectations. The country contributes to EU27 funding for a share of around 13.4% (2011 forecast, source MIUR); against this funding, Italy obtained funding from the FP7 to the tune of around 8.43% of the general programme budget, a share which rises to 9.46% if we consider the part of the FP7 budget obtained by Member States alone. Even so, the gap between participation in Union funding and the share received for FP7 is still negative (-3.94%) whereas the leading countries in scientific research show decidedly positive balances (UK 4.4; Sweden 1.76; Finland 0.97).



Graph 3 Participation of Italian regions in FP7 as at March 2012; comp. %. Italy = 100



Source: Apre Discussion paper, April 2012

The participation of Italian regions in FP7 is characterised by a surprising lack of linearity; the first 5 Italian regions absorb around  $\frac{3}{4}$  of the national total. The main recipient is the Lazio region which collects 608.5 MEUR of funding (this value depends in part on the fact that the projects participated in by the CNR institutes operating in the various Italian regions, which amount to around 165.0 MEUR, are all booked to the central headquarters in Rome; the same goes for the INFN research projects), followed by Lombardy with 495.0 MEUR and further behind Tuscany with 226.5 MEUR, Piedmont with 222.1 MEUR and Emilia Romagna with 169.5 MEUR.

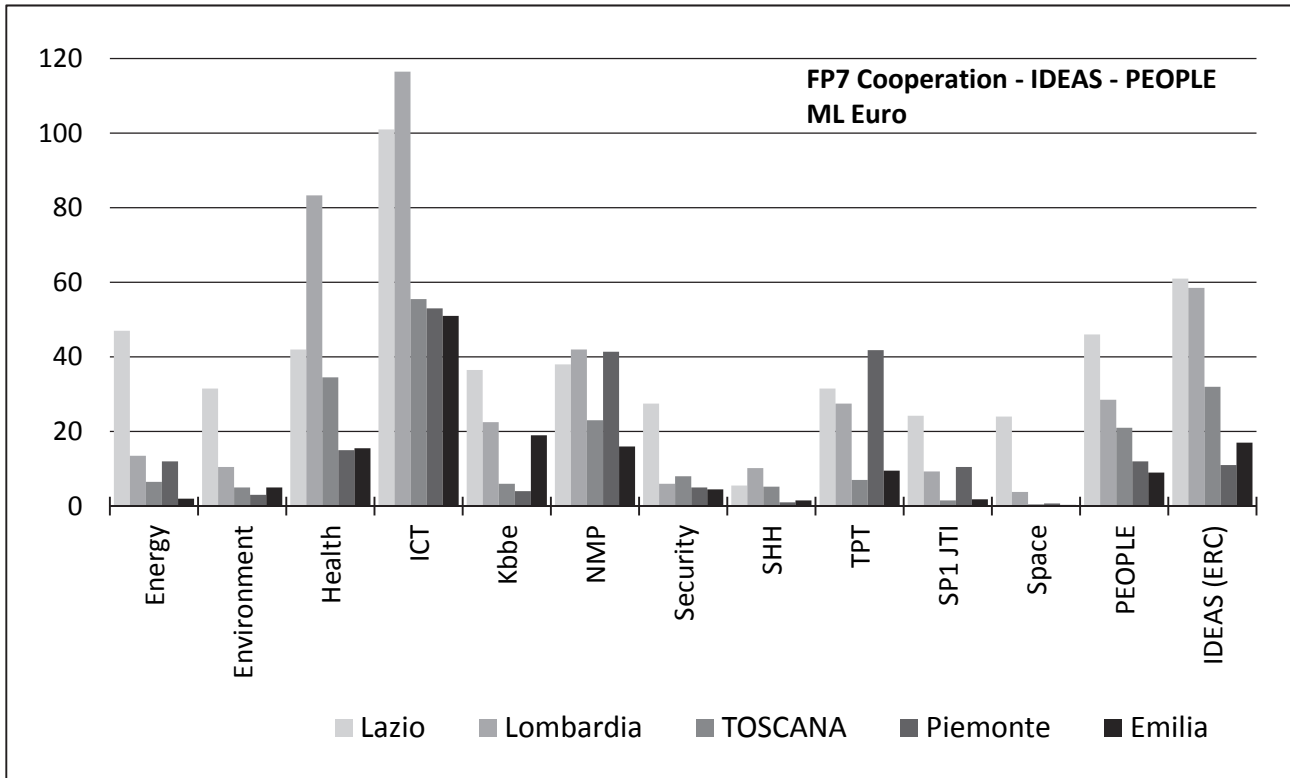
Naturally these results depend in part on the demographic size of the regions, the presence of central headquarters of national research institutes, the number of researchers and the presence of research infrastructures.

In relative terms, considering funding per single research worker<sup>2</sup>, the picture changes radically: with the exception of two small regions like Trentino Alto Adige and Liguria – where the presence of some highly esteemed institutions cause the ratios spring to anomalous values of over 25,000 euros per capita – Tuscany, with 20,750 euros per capita of funding from FP7 projects, ranks immediately behind

<sup>2</sup> The per capita values were calculated using Eurostat data on research personnel in the government and higher education sectors for the last available year (2009), considering researchers only.

Lazio (21,250 euros without considering the CNR data), way ahead of the other Italian regions of significance in these terms (Piedmont 16,050; Emilia Romagna 11,500 euros).

Graph 4 Participation of Italian regions in FP7 as at March 2012; comp. %. Italy = 100



Source: Apre Discussion paper, April 2012

The disciplines in which Tuscany's participation in FP7 stands out on the national panorama are health and ICT (with respectively around 35 and 55 MEUR of funded projects) and the nanosciences, nanotechnology, new materials and production technologies sectors (NMP with around 20 MEUR). Its participation in the transport sectors (TPT) is also significant, as well as in the knowledge based bio-economy – KBBE (food, agriculture, fisheries and biotechnology), and to a lesser extent in the socio-economic sciences and humanities (SSH) and the security area.

Tuscany's participation in the People programme initiatives is particularly significant, with the Tuscan research centres receiving grants and funding amounting to more than 20 MEUR. The same way participation in IDEAS is highly remarkable: Tuscany with 30 MEUR is the third region in the national ranking.

Moreover Tuscany participate in the capacities programmes, roughly, for an additional 16,5 Meuro.

Lastly, to further underline Tuscany's capacity to latch onto important research opportunities at the European level, we must mention the impressive results achieved in the preparatory stage for the Future and Emerging Technologies Flagship (FET Flagship Pilots). Indeed, also thanks to support from the regional administration, Tuscan research centres qualified for no less than three of the six pilot activities funded in 2011, from which the full FET Flagship Initiatives will be chosen in 2013. In the first initiative, *“Robot Companions for Citizens”*, the Scuola Superiore Sant’Anna Biorobotics Institute plays the role of consortium coordinator; in the second *“IT Future of Medicine”*, Florence University’s CERM appears among the 25 main project partners; in the third, the *“Human Brain Project”*, Florence University’s LENS (European Laboratory of Non-linear Spectroscopy) ranks among the 5 Italian centres collaborating in the project.

Another example of research excellence refers to the field of care and preservation of the cultural heritage. Tuscany’s standing in this field is highlighted by the fact that the Horizon 2020 programme proposal for the future European infrastructure in the cultural heritage sector is being prepared by the National Optical Institute, along with the *“Nello Carrara”* Institute for Applied Physics and the CNR Institute for the Conservation and Valorisation of Cultural Heritage which together make up a crucial element of the European research infrastructure, Charisma.

In the field of biophotonics, i.e. photonics for life sciences and health, Tuscany, thanks to the Institute of Applied Physics and LENS, is a core member of the Photonics4Life Network of Excellence. In this frame, Tuscany is committed to the organisation of the next ERANET+ call on biophotonics.

Furthermore, Tuscany also demonstrates a good capacity to attract funding for research on the national front: in the period 2001-2009, for projects of national interest (PRIN), Tuscan universities obtained 177.3 MEUR of funding, that is 11.46% of the total funding granted to Italian universities for this research area (table 5).

The capacity of Tuscan research centres to compete in the public funding system becomes even more significant if the amount of the funds obtained is divided by the number of research personnel in each disciplinary field: indeed the regional average is 28,850 EUR per research worker, around 34% more than the national figure (21,590 EUR). If we are to break up the data according to the single disciplinary areas Tuscany good performance is crystal clear; Tuscan researchers avail of a greater average amount of funding than the national average figure in almost every disciplinary sector.

Lastly, it is worth underlining Tuscany's position as to the percentage of successful projects, that is, the number of projects accepted for funding out of those presented: the Tuscan figure is 35%, six points higher than the national figure.

*Table 5 Success rate of PRIN projects presented and funding per research worker by discipline (% values) (Years 2001-2009)*

Scientific discipline	Project's success rate (% values)		Euro per R&D personnel ricerca (€)	
	Tuscany	Italy	Tuscany	Italy
1- Mathematics and informatics	55%	43%	21.650	13.654
2- Physics	40%	27%	52.140	39.311
3- Chemistry	29%	34%	68.618	44.489
4- Earth and Planetary Sciences	38%	34%	46.009	33.582
5- Biology	32%	27%	31.171	29.616
6- Health sciences	16%	26%	30.510	24.509
7- Agricultural and animal sciences and technologies	10%	26%	25.825	24.264
8- Civil engineering and architecture	11%	26%	19.367	21.466
9- Industrial Engineering, computer science, IT	14%	24%	23.258	21.078
10- Ancient history, philology and literature, history of arts	46%	33%	25.004	15.448
11- History, philosophy, psychology and science of education	32%	32%	20.998	12.926
12- Law	38%	37%	15.426	9.229
13- Economics and statistics	19%	27%	13.607	8.979
14- Political Sciences, sociology	41%	45%	35.305	21.858
<b>TOTAL</b>	<b>35%</b>	<b>29%</b>	<b>28.850</b>	<b>21.593</b>

Source: MIUR 2012

In this regard, the disciplinary sectors with a particularly high percentage of projects funded compared to the national average are mathematical and IT sciences; physics; and classical studies in ancient philology, literature, history and art.

## University education

In order to provide a complete picture of the research system in Tuscany we cannot neglect the educational role of universities and schools of higher education; the formation of potential researchers indeed starts with the numerous degree courses (3-year degree, 5-year degree and masters programmes) offered by the six Tuscan universities which provide an in-depth preparation in all the main disciplinary spheres.

In Tuscany University students – both undergraduate and postgraduate – amount to almost 130,000, variously distributed among the university institutions located in the region:

Table 6 Students enrolled on undergraduate and postgraduate courses AY 2010-2011

Universities	Pre-lauream	Post-lauream	
		Total	Foreigners
University of Florence	54.889	3.373	189
University of Pisa	48.288	2.760	171
University of Siena	16.205	1.764	140
University for foreigners of Siena	623	105	21
Scuola Normale Superiore	455	189	33
Scuola Superiore Sant'Anna	250	439	139
IMT Lucca	0	93	40
Institute of Human Sciences (SUM)	0	65	6
<b>TOTAL</b>	<b>120.710</b>	<b>8.788</b>	<b>739</b>

Source: MIUR 2010

The high standard of education offered by Tuscan universities can also be inferred by observing the data on the regional systems' capacity to attract students, both from other Italian regions and other countries. Indeed in Tuscany the percentage of foreign students enrolled at university amounts to 3.6%, a figure that accounts for around 10% of the total number of foreign students registered at Italian universities. Furthermore, more than 30% of the students enrolled at Tuscany's universities come from other Italian regions, confirming the strong appeal of the Tuscan university system; vice versa students resident in Tuscany who decide to study outside the region account for only 9% of the total number of students enrolled in university (source: IRPET elaborations of MIUR data).

## Knowledge transfer and innovation

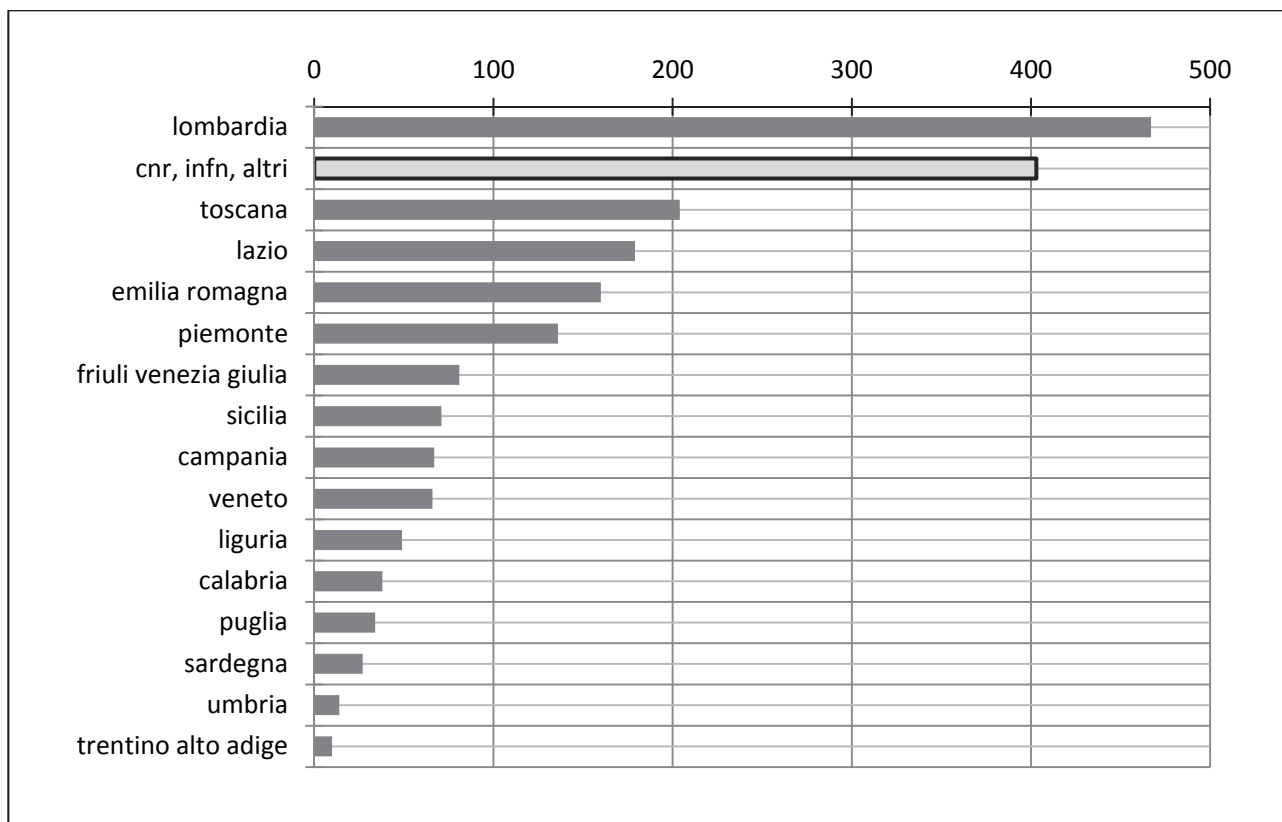
Tuscany's universities and schools of higher education are also actively engaged in the so called *third mission* alongside research and higher education, that is, the transfer and valorisation of knowledge to foster innovation. It is well known that, with respect to other countries with mature industrial development, in Italy it is only quite recently that university institutions began to systematically cultivate these functions relative to the third mission. This is also true for the Tuscan university institutions (universities and schools of higher education): some had made an earlier

and more energetic start a decade ago, while others have been speeding up over the last few years.

From the last two NETVAL reports (Network for the Valorisation of University Research – VIII: 2011, IX: 2012) we can grasp two synthetic performance indicators on the third mission. Even though no single Tuscan university institution is present among the top Italian performers, the “regional system” occupies a leading position in the national ranking.

The first indicator concerns **portfolios of patent applications** deposited between 2000 and 2010, including patents granted, net of patents sold or withdrawn, from the first 35 Italian patent filing research centres broken up by region.

Graph 5 Patent applications per region made by universities and research institutions between 2000 and 2010



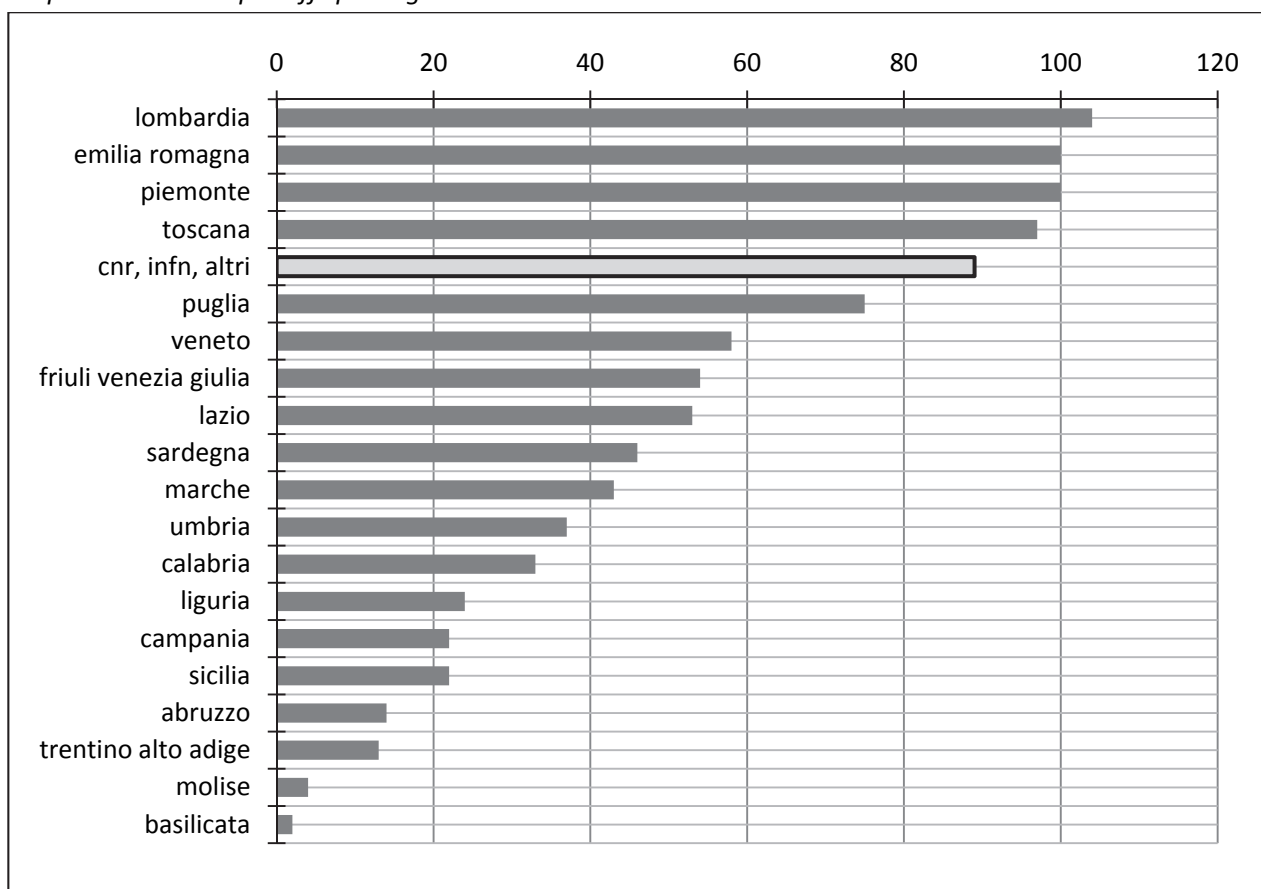
Source: Netval elaboration on ORBIT data. VIII Neval report (2011)

The Tuscan figure has the contribution, in order, of Pisa, Siena and Florence universities and the Scuola Superiore Sant’Anna, and amounts overall to 10.2% of the national total. In comparison with the other regions, Tuscany takes second place after Lombardy. Moreover, this position could also be strengthened, in territorial terms, if we consider the localisation of the CNR institutes and INFN where these

national public research institutions' patents come from. Indeed it is well known that after Lazio, Tuscany is among the regions that host the highest number of institutes and research bases of these institutes.

The second indicator concerns the spin-offs of Italian public research as at 31.12.2011. It not only includes the enterprises officially accredited as spin-offs from public research institutes, but also enterprises whose origin can be traced back to research carried out in these institutes. Graph 6 shows the spin-off data grouped by region.

Graph 6 Academic spin-offs per region as at 31.12.2011



Source: Netval elaborations on Laboratorio Main (Scuola Sant'Anna) data. IX Netval report (2012)

The Tuscan figure has the contribution of Pisa, Siena and Florence universities and the Scuola Superiore Sant'Anna, and makes up 9.8% of the national figure. In the comparison with the other regions, Tuscany is situated in the small group of 4 regions that hold a pre-eminent position over this indicator. Once again, the position would probably be strengthened, in territorial terms, if we were to consider the localisation of the CNR and INFN institutes.

In addition to spin-offs and patents, the Tuscan university institutes actively use other tools for transferring the knowledge developed to the production and local systems. To support these activities universities make use of allotted structures (e.g. knowledge transfer offices), at times shared with external institutes (e.g. technology parks and incubators), and with a solid view to regional coordination (recent examples are: the Network for the Transfer of Knowledge and the Industrial Valorisation of Research (ILO-NOVA), the Tuscan Unit of the Agency for the Promotion of European Research (APRE Toscana), and the Protocol for European Research).

## **Regional policy**

Considering the central importance of research and innovation for Tuscan growth, the sustainability of future growth and the improvement and valorisation of work and skills, the regional administration adopted a special normative tool some time ago: law no. 20 dated 27 April 2009 containing *Regulations on the Subject of Research and Innovation*. This tool outlines the central elements of the governance model for the regional research and innovation system and defines the fundamental principles in order to strengthen the integration and coherence of regional policies on the matter.

Of particular importance are the principles that law no. 20/2009, in agreement with the *Researchers' European Charter*, lays down with respect to gender equality, equal opportunities and the fight against discrimination, which must be observed in all the regional research programming activities.

Law no. 20/2009 also sets out that, at the same time as the regional development programme (PRS), the region should adopt a multi-year programming document, of a similar duration to the latter, specifying the strategic guidelines on the subject of promotion and support of research, transfer and innovation: the *Multi-year Action Plan for Innovation and Research (AIR)*. This programming document sets out the priority lines of intervention, gives a picture of the financial resources allocated and defines the methods for coordination between the sector programmes in terms of interventions in research, innovation, technology transfer and higher education.

The AIR, approved by resolution of the Regional Council no. 46 dated 06/07/2011, unifies the strategic choices made by the various regional sectors in a coherent framework. It gives a detailed definition of the blueprint for the policies on the matter and outlines the main tools to be implemented for the governance of the



regional research and innovation system. Below we set out some of the main indications given in the AIR and some changes deriving from its implementation.

## **Governance of the regional research system**

Given that the research and innovation activities have systemic characteristics, a crucial element for their promotion resides in the public institution's capacity to promote continual and systematic comparison between the various entities making up the regional research system, whether they be universities and research centres, enterprises, technology transfer actors or institutions, and to promote effective coordination. To this end, Regione Toscana has implemented a multi-level governance system for the Tuscan protagonists of research and innovation.

On the side closest to research institutions, the governance is divided into two levels. On one hand, the regional governance component, aimed at coordinating the actors in the Tuscan research system. This is implemented through the *Regional Conference for Research and Innovation*, a permanent board structure with consultation functions, comprising representatives of the universities, research centres, science and technology parks, enterprises and trade unions. On the other hand, the *governance between institutional levels* component is set up to strengthen the coordination between the regional action and the national and European policies on the matter. At the national level this end is achieved through the IX Italian Regions and Autonomous Provinces Coordination Commission which is competent for research and innovation, with Tuscany holding the chairmanship. At the European level, governance has been provided by strengthening the Regione Toscana institution's level of representation in Brussels, with the development of a receiver and transmitter *antenna* function to link with the Regional Conference for Research and Innovation. The *antenna* will help to monitor the European research and innovation scenario better and strengthen the regional research system's active participation in the opportunities offered by the European Union.

On the side closer to enterprises, Regione Toscana has instead established other governance instruments. First of all it has set up twelve *innovation poles*, and, subsequently, as part of the national research policies, it has established five *technological districts* (which join some of the innovation poles established previously). They concern life sciences; ICT and telecommunications technologies; renewable energy technologies; railway, high speed transport and network security technologies; cultural heritage and sustainable city technologies. The technological districts represent territorial aggregations of enterprises, universities and research

institutions guided by a specific governance body. They focus on specific areas of science and technology and their relative applied research and experimental development projects.

Finally, a further level of governance lies inside the regional institution, that is, coordination between the components of the administration responsible for the various lines of support for research and innovation. Regione Toscana is investing in creating central and formalised coordination of all the actions that, directly or indirectly, have an effect on the regional research and innovation system, in order to guarantee greater integration between the different actions intervening on various aspects of the regional research system.

### **The regional flagships: the strategic lines of Tuscan research**

In response to the Regional Administration's programmed goals, formalised in the *Action Plan for Innovation and Research (AIR)*, the *Regional Conference for Research and Innovation* has singled out five strategic lines that will have to be upheld in the mid- and long-term (7-15 years); these lines of research cover a strategic role for Tuscany since they are closely connected to the paths of social and economic development that the regional administration envisages for the future scenario. They have broad bases in the Tuscan universities and points of excellence in the same universities' networks of departments and centres as well as in the other research bodies located in Tuscany.

Life Sciences and Neurosciences: the new frontiers of medicine find expression in the Tuscan research centres' wide-ranging, internationally important projects: personalised and preventive cures, regenerative medicine, system biology and advanced genomics. Furthermore, studies on brain functions, integrated psychophysical exploration technologies, and high-resolution brain imaging for the functional and morphological analysis of neural circuits, and in general digital imaging for radiodiagnostics, high precision dosimetry for treatment planning in both conventional tumor radiotherapy and in hadron therapy using particle beams are largely used terms in many Tuscan research centres.

Robotics and Biorobotics: closely connected to life sciences, this branch sees important Tuscan centres of clear value at the heart of the international panorama. Ongoing research refer to new generations of robots ranging from nanorobots (including implantable system), to "neuroprostheses" aimed at recovering mobility and sensorial functions, to human's dimension robots, versatile and "intelligent".

These robots find application in strategic fields such as surgery, diagnostics, and rehabilitation, intelligent prostheses, neurorobotics, security, aid to the elderly and disabled based on “ambient assisted living” solutions, education and entertainment, but also in adverse working conditions and in environmental, marine and underwater applications, in particular for the safeguard of archaeological finds.

Knowledge acceleration: ICT research is organized into the following main axes: high performance computing, numerical and mathematical methods, networks and telecommunications, electronics, knowledge and software technologies, computational linguistics and visual technologies. Tuscany aims to become a metropolitan-lab where the most innovative ICT technologies can be designed, implemented and tested in order to address the new societal challenges such as cultural heritage, enhanced society, e-health, green economy, smart cities and communities and smart grids. This is due to the unique concentration in this area of excellent researchers, a pioneering vocation for ICT, and a dense eco-system of SMEs, whose dynamism and small size make technology transfer very effective and active in this region.

Photonics, silicon Photonics, high-energy Physics: in Tuscany’s advanced research centers photonics, silicon, new frontiers of telecommunication are the keywords. Cutting-edge technological achievements have been obtained there for the radiation detection apparatuses at the large particle accelerators (e.g. for the discovery of the Higgs boson); or in the fields of superconductive materials, of ultra-high vacuum technologies, of cryogenics. Crucial and innovative applications have also been developed in the field of Science for the preservation of Cultural Heritage, which thanks to sophisticated techniques based on lasers, particle beams and nanotechnologies makes it possible to diagnose and cure deterioration problems, to restore art treasures and date archaeological finds. Also to be emphasized is the branch of biophotonics, where Tuscany is in the vanguard for laser technologies, microscopies and tumor therapies based on nano-biophotonics.

New Materials and Nanomaterials: Nanoscience together with the study of new materials are of fundamental importance for the research in Tuscany. Together with numerous research groups operating in the different Institutions, a number of research centers specifically devoted to these topics have been created. Nanotechnologies are at the base of a wide spectrum of projects ranging from fundamental science to realization of new devices, and applications to energy technology and life science. In particular Interaction with the life sciences sector favours research into new materials to repair and regenerate human tissues but also develop new non-toxic nanocarriers for drug delivery and magnetic nanoparticles to cure tumours, backing up a new generation of drugs.

Linked to these five vertical lines of research are as many transversal ones. These correspond to five sectors that are fundamental for the region to acquire an authoritative leading position in Europe: Cultural heritage; Energy; Space; Environment, climate, agriculture and forests; and Social innovation.

In the sign of an ideal continuity within its historical and cultural traditions, the Tuscan Research System proposes some research sectors as a priority, thus representing the fundamental elements of a systemic cultural pathway able to elaborate creative proposals as well as to produce innovation in the sustainability of Human Biosphere.

Cultural Heritage: Tuscany offers a well-structured research system able to promote actions enhancing innovation potentiality and creativity as well as the social function of Cultural Heritage. Besides the scientific research focusing on Conservation of Cultural Heritage, the Tuscany Region was proposed for the role of coordinator of the European research infrastructure in the field of HORIZON 2020, the Tuscan Research System is also the harbinger of a social involvement in Heritage fruition. In this way, the cultural asset – both tangible and intangible – becomes the key element for a new world language which can also be devoted to migrant and emerging communities, towards the setting up of a new identity pathway which will stimulate an ever greater social cohesion.

Social Innovation: According to what already planned by the European Commission, Social Innovation represents a strategic asset for Tuscany in order to foster sustainable Innovation within the next ten years. Attention focuses on:

- effective good governance models, even more active, both at a national and international level;
- stating Smart cities beforehand, the development of electronic services addressed both to people and firms, thus allowing a more effective identification of disadvantaged groups and a better distribution of services;
- the impact of the increasing contamination between enterprise modalities, business ideas and market principles on the business field, on the one hand, and on the no-profit world and social entrepreneurial activities, on the other.

Energy: Energy supply as well as energy quality represent one of the most important challenges for Europe. In this field, Tuscan researches contribute to promoting renewable energy utilization and energy saving, a very effective system to face the problem, for the time being. Among several projects, SMART-CITY E-MOBILITY is a very important one, aiming to relieve traffic congestion by means of the development of electric transport based on two-three-wheeler vehicles. Also geothermal energy, a resource with great potentialities to be achieved in the future,

represents a very important research issue in the field of removable energies for Tuscany.

Environment, climate, agriculture and forests: Tuscany boasts an important tradition of excellence in the field of agricultural research, as testified to by Accademia dei Georgofili, the most ancient agriculture scientific academy all over the world. The main research lines concern sustainability of quality foodstuffs, the application of agrarian biotechnologies to energetic productions and foodstuffs, the role of agro-forestry systems to control climate change, energy production and environment protection.

Space: Looking-ahead to the 10-15 years mid-term, users (people and other entities) will require the access to a multiplicity of services and available applications provided and supported by a convergent and integrated system of technologies ('an integrated system of systems'). To this end Space technologies can obtain a breakthrough by the integration of communication, location, sensing functionalities, earth observation, together with transport and mechanical means, made available to clouds of users by a self-consistent heterogeneous and flexible system. Space technology will play a major role in the monitoring of atmosphere (eg: to measure dust and pollution concentrations), of land and oceans (eg: to mitigate natural disasters), of human activities (eg: to guarantee security of air, land and maritime transport). The Space component, in this context, is essential to provide the necessary functionalities to the Human Biosphere, including physiology of life in absence of gravity.

Furthermore, it needs underlining how the policies supporting innovation and technology transfer created by Regione Toscana as part of the Key Enabling Technologies<sup>3</sup>, are fully integrated and coherent with the spheres of research and application in the vertical and horizontal strategic lines of research defined above. The innovation poles and technology districts promoted by the regional administration indeed concentrate their innovation and transfer activities on strategic sectors that follow the vertical and horizontal lines mentioned above.

The regional technology districts blend together industry and research bodies' research in the following strategic sectors: renewable energies; life sciences; cultural heritage and sustainable city technologies; railway and transport technologies; ICT, robotics and telecommunications.

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<sup>3</sup> Key Enabling Technologies (KET): nanotechnologies, micro/nanoelectronics, industrial biotechnologies, photonics, advanced materials, advanced manufacturing technologies; European Commission, D-G for Enterprise and Industry.

The innovation poles concentrate their innovation and transfer activities in 12 sectors: in addition to the 5 district spheres we can add the following sectors fashion, paper, stone, furniture and furnishings, boating, optoelectronics and aerospace.

The coherent development of the Tuscan research system's 5 vertical and 5 transversal strategic lines of research will permit:

- rapid construction of multi-disciplinary knowledge networks;
- knowledge and modelling of highly complex and heterogeneous systems in order to forecast and anticipate their conduct;
- an increase in the intensity of research with a more efficient use of the available resources.

The *Regional Conference of Research and innovation* activities will continue over the years to come, in order to get a better idea, within the topic areas indicated above, of the most important research perspectives for the regional system, the projects underway of greatest scope and importance, the areas of excellence already achieved and those that need further sustaining.

## **Research and innovation support policies**

The Tuscan regional administration offers support to the research and innovation system on a variety of fronts and using a wide range of tools.

Taking the dualism between the public research system and capacity of the private component in due consideration, a particular effort is devoted to the creation of joint ventures between the universities and regional research centres, on one hand, and the production system, public administrations and, more in general, the regional society, on the other.

The set of actions implemented by the regional administration can be traced back to the following main categories.

Funding of frontier research: even though the funding of research remains a prerogative at the national and EU levels, the wider-level research priorities do not necessarily meet the specific requirements of the regional context in terms of its particular necessities and opportunities: the policies supporting Smart Regional Specialisation also need to be able to direct research and innovation activities towards the specific needs, spheres of competence and opportunities offered by the regional territories. Therefore, the regional institution finds an operating space in

the funding of frontier research projects that are strategic for Tuscany because: a) they fall into the technical and scientific spheres in which the regional scientific and production communities can strive to be at the frontier of knowledge and promote their techno-productive leadership; b) they are carried out by top research groups and/or infrastructures that can aspire to reach an outstanding position in the European competition for research funds; c) they aim at particularly important results in terms of the regional system's necessities. In promoting frontier research particular attention is paid to those projects that meet the interests of regional enterprises and aim for rapid results even if they cannot directly be used in production applications. The Tuscan regional administration plans to invest in this area, using various sources of funding (European, national and regional), to the tune of around 82 million euros in the period 2011-2013.

Support for industrial research and experimental development: through public calls for proposals, generally subject to the regime of state aid, to co-fund industrial research and experimental development projects presented by enterprises, preferentially in partnership with the regional research system. The aim is to achieve greater competitive capacities through the development of new products, new processes and new organisational methods. These operations are aimed at promoting innovative activities, both in terms of processes, products and/or organisation and marketing, and at making investments in advanced technologies. On one hand their objective is to develop the most modern sectors of the economy and on the other to upgrade the technology in traditional production industries. The goal pursued is explicitly to give the regional production activities a greater competitive edge by increasing their knowledge and technology content and hence to support regional growth and the creation of skilled jobs that respond to the expectations of the most qualified young people. In the period 2007-2013 the resources programmed for the purpose exceed 252 million euros. Further resources may become available for the technology districts that win resources released with the next MIUR (Ministry for Education, University and Research) calls for proposals.

Higher education support and guidelines: through the funding of doctorate scholarships and research assignments in the strategic disciplinary areas indicated in the AIR *Action Plan* for the other research support actions; these resources also set out incentive mechanisms to favour cooperation and collaboration between universities and between universities and the business world. Instead other actions promote the interregional and international mobility of students, researchers and workers in order to favour their professional growth and competitive edge. The resources allocated to this set of activities in the period considered amount to around 44 million euros.

Research valorisation activities: through favouring the formation of spin-off enterprises from the research system; funding specific training for the university liaison offices; supporting the patenting activities of the university system and enterprises in specific sectors (life sciences); creating opportunities to publicise the results of the funded research projects, both among enterprises and the region's citizens.

Technology transfer: these activities are implemented both by funding service centres and innovation poles which can grasp the enterprises' technical and scientific needs and satisfy them autonomously, or put the enterprises in contact with the competent research centres and universities. This both supports the regional enterprises' demand for skilled services, and provides the universities with research orders. The resources dedicated to these types of activity in the period 2011-2013 amount to around 34 million euros.

## **Cooperative agreements between European Regions**

To support the Tuscan Research and Innovation System and foster improved integration within the European context, the Regional Government and the Regional Research System intend to promote the creation of specific collaborative framework agreements, establishing cooperation between individual regions. These are based on strategic plans aimed at developing:

- alliances to build arrangements and common infrastructures for presentation to the European Commission and other institutions within the context of specific policies linked to research sectors of common interest;
- collaborative projects between research centres throughout the territory in order to foster common research, submit proposals to European calls, and promote common research programmes;
- cooperation in the field of human resources via researchers exchange (Marie-Curie Programme, ERC), the creation of common PhD courses that foresee the mutual recognition of qualifications, professor and researcher exchange, the development of 'Industrial PHD' schemes and support to collaborative projects within academia and industry;
- the joint creation of incubators and spin-offs;



- P2P initiatives (Public - Public Partnership) as part of new strategies generated by the European Commission with regard to research and innovation<sup>4</sup>;
- common applications together with partner regions aimed at managing components of the upcoming 'Horizon 2020' in areas of strategic interest in line with cohesion policies.

The criteria used to choose regional partners will primarily be guided by the complementarity of research centres' strategic priorities in partner regions and their common interests in the field of research policies and innovation. Partner choice will also be guided by the presence of strong collaborative projects linking academic institutions and research centres and by common features in the regions' industrial systems and investment strategies.

Ultimately, construction of the partner network will be guided by an exact evaluation of common potential needs and the pursuit of synergies with the research and innovation policies planned and implemented by Member States and the European Commission.

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<sup>4</sup> "Partnering in Research and Innovation" COM(2011) 572 final: 21.9.2011.



In a period facing debt crisis and economic difficulties, investing in Research and Innovation now and in the future is one of the major challenge of the Tuscany Region, but it is also the only way to fight against social distress and poverty, as well as to ensure growth and a faster economic recovery. We shall imagine and construct our future and our society in the next 10 – 20 years, by creating the conditions for a path from excellence science to competitive products and from sustainable development to a new and inclusive society.

**STELLA TARGETTI**  
Regional Minister for  
Education University and Research

**ENRICO ROSSI**  
President Tuscany Region

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Contact:

Directorate General for Regional Competitiveness and Capacity Building  
Area of Research Coordination

Piazza dell'Unità italiana,1  
50123 Firenze - Italia  
tel. +39 055 4382050  
fax +39 055 4382060  
email [areacoordinamentoricerca@regionetoscana.it](mailto:areacoordinamentoricerca@regionetoscana.it)  
web [www.regione.toscana.it/istruzioneericerca/ricercaformazione/index.html](http://www.regione.toscana.it/istruzioneericerca/ricercaformazione/index.html)