SPANISH STRATEGY FOR SCIENCE AND TECHNOLOGY AND INNOVATION 2013-2020

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0. OVERVIEW

The SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION promotes the capacities of the *Spanish Science, Technology and Innovation System* and enables collaboration between all the stakeholders of the *System* while increasing the social and economic returns from investment in RDI. The SPANISH STRATEGY envisages RDI from a general and multi patterned perspective through different forms of interaction among all the stakeholders in the *System*. Related to this, the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION defends the importance of scientific and technological progress as an indisputable element of social progress. Although this is a necessary condition, it is not sufficient; one must also have the backing of society, a society open to innovation and that welcomes the development and adoption of new ideas and their inclusion in new processes, products and services. It is, therefore, a STRATEGY that is open to all stakeholders, one that fosters collaboration among them, encouraging them to internationalise, and, above all, inspiring them to seek solutions to the principal challenges facing the Spanish society, which mostly coincide with major global challenges.

The **SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION 2013-2020** was launched in 2012, at a time when the country was experiencing serious economic difficulties, which have an impact on the *Spanish Science, Technology and Innovation System* also. Since 2010 funding of the latter has been gradually decreasing (after decades of sustained growth) with respect to both public and company investment. The challenges are significant and require major reforms and the adoption of new instruments for promoting RDI. Funding of the *Spanish Science, Technology and Innovation System* is a critical aspect, but it is not the only challenge to be faced in the context of the STRATEGY. Increasing international competition in talent and knowledge, the differences observed in innovation or the weaknesses of a *System* which has one of the lowest rates of business participation in RDI are equally critical aspects. It is therefore essential to define a strategic framework for RDI policies to promote structural reforms, establish incentives and determine the objectives and efforts required to create the RDI capacities that will make Spain a country of innovation, contribute to social and economic progress and reinforce our international leadership in a global setting.

The SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION 2013-2020 was produced jointly by the General State Administration and the Regional Administrations. The following have also been taken into account in drafting the Strategy: (1) the baseline conditions and the true situation of the *Spanish Science, Technology and Innovation System*; (2) the need to direct RDI activity towards the major challenges of the future; (3) commitment to sustainability and the strengthening of the available RDI capacities and the search for the right balance between basic research, guided research, applied research and innovation, and (4) the elimination of existing barriers between research and innovation through dialogue and collaboration between all the stakeholders in the System, thereby enabling the generation of a natural flow of communication between basic research and its potential technological applications, in addition to disseminating.

The Strategy was drafted in a good environment of collaboration among different ministries ensuring the inclusion of sectorial policies and the broad spectrum of the innovation system. Except for the vast consultation with the Spanish scientific, technological and business community, the final draft document went through the open process of public consultation during with more than 1400 comments were received and the content of the Strategy was enriched as appropriate.

The SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION provides an overview of the System and defines the main objectives to be achieved in the spheres of action of the Public Administrations while it remains in force. However, it does not address the instruments specifically designed for achieving these objectives; these will be developed in the corresponding scientific, technical and innovation research plans.

1. INTRODUCTION

Spain is facing one of the greatest economic challenges of recent decades. This makes necessary to adopt major structural reforms, which must be accompanied by measures aimed at fostering the creation of employment and strengthening the foundations of our social, economic and business development for the future.

The impact of the economic and financial crisis, the efforts to achieve fiscal consolidation and the significant cost to our society of high unemployment rates must not let us forget that the social welfare of the country and its future development and economic growth are linked to education, to the capacity for generating know-how in the areas of science, technology and innovation and to the need for business leadership in RDI. These will act as levers of change and progress in a context of accelerated transformation and strong international competition.

Since 2008 the progressive erosion of the competitiveness of the Spanish economy has served to highlight the urgent need to come up with an ambitious project setting out measures designed to promote the generation of scientific and technical know-how, to apply the latter to and promote it within the productive and societal fabric, and to foster the generation and adoption of key innovations with a view to modernising the country as a whole.

These measures must form part of a RDI political agenda which includes coordination between the actions of the General State Administration, the Autonomous Regions and the European Union, together with the design of efficient coordination mechanisms among the stakeholders of the *Spanish Science, Technology and Innovation System*. In this context, the priorities and objectives of the STRATEGY ON SCIENCE AND TECHNOLOGY, which will be in force during the 2013-2020 period, are shared by all the Administrations involved in drafting it and follow a proposal agreed with the stakeholders of the *System* who have taken part throughout the established public information process.

The structure of the SPANISH STRATEGY represents an effort to align Spanish policies with the RDI objectives pursued by the European Union. These are defined in the new framework programme for the funding of RDI activities, «Horizon 2020», which is intended to foster the active participation of the stakeholders of the Spanish Science, Technology and Innovation System in the development of the European Research Area and to facilitate access to the sources of funding existing in the EU. In this respect, the SPANISH STRATEGY will contribute to the objectives established in the «Europe 2020» strategy, the «Innovation Union», the «European Research Area» and the framework programme «Horizon 2020», albeit taking into account the specific requirements of the *Spanish Science, Technology and Innovation System*, its scientific, technological and innovation capacities and the general interests and characteristics of the country and its regions.

In accordance with the Law on Science, Technology and Innovation, of 1 June 2011, approved with a broad parliamentary consensus, the SPANISH STRATEGY ON SCIENCE AND TECHNOLOGY AND THE SPANISH STRATEGY ON INNOVATION are instruments of the new model of governance of the *Spanish Science, Technology and Innovation System*. Although the Law views both Strategies as independent documents, the Ministry of Economy and Competitiveness, through the State Secretariat for Research, Development and Innovation, in agreement with the Science, Technology and Innovation Policy General Council, have agreed to incorporate the two Strategies conceptually and operationally in order to establish a strategic framework to identify the priority lines of action and highlight the general objectives, considering RDI activities as an ongoing, complex process with multiple interaction among the stakeholders. This process, referred to in the text as «*from the idea to the market*», does not respond to a linear logic nor are its results easily predictable, and attempts have been made to reflect this in the Spanish Strategy and in the subsequent actions of the Administrations.

With a view to addressing the challenges and needs of the *Spanish Science, Technology and Innovation System*, of leveraging its capacities, strengthening the stakeholders and their relations, boosting levels of business participation in RDI activities and increasing the social and economic returns from the public investment to be made, the FRAMEWORK OF THE SPANISH STRATEGY ON SCIENCE AND TECHNOLOGY AND ON INNOVATION is structured around:

- **5 BASIC PRINCIPLES**.
- **4 GENERAL OBJECTIVES** divided into 18 specific objectives.
- **6 PRIORITY LINES OF ACTION**.
- **6 COORDINATION MECHANISMS**.

The BASIC PRINCIPLES of the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND ON INNOVATION comprise the criteria shared by all the stakeholders and these must be observed in the definition and implementation of the public RDI policies. They are:

I. The COORDINATION OF THE POLICIES for RDI of the Public Administrations with the European Union, and with the other sectorial policies, in order to generate the necessary synergies and complementarities. This principle involves, in turn, the co-responsibility of the relevant Administrations and the adoption of shared criteria as regards management, evaluation and, where applicable, the implementation of co-financing models.

II. The DEFINITION OF A STABLE PLANNING FRAMEWORK to enable: (i) structuring of investments and actions in RDI in both public and private sectors and (ii) improvement of the planning of the actions promoted by the Public Administrations, thereby increasing their efficiency.

III. The APPLICATION OF QUALITY, RELEVANT AND SOCIAL IMPACT CRITERIA; those that are internationally recognised in the allocation of competitive public resources designed to promote RDI activities, both in the evaluation of technical-scientific merits, with assessment by independent international experts, and the evaluation of technological merit. In the latter case, industrial feasibility, market proximity and the economic impact of the results must be taken into account.

IV. EFFICIENCY AND ACCOUNTABILITY in all Public Administration actions linked to the promotion of RDI to foster a stable framework of relations among stakeholders in the medium and long term and to ensure that society is appraised of the results.

V. The INCLUSION OF THE GENDER PERSPECTIVE in public RDI policies to correct the loss of human capital associated with the uneven distribution of women and their professional development in the areas of scientific and technical research, both in the public and business sectors. This principle involves the inclusion of the gender perspective in the content of scientific, technical and innovation research in order to enrich the creative process and the obtaining of results.

The overall goal of the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION is to promote scientific, technological and business leadership in the country and to increase the capacities for innovation of Spanish society and the Spanish economy. FOUR GENERAL OBJECTIVES are established:

1. The RECOGNITION AND PROMOTION OF **TALENT IN RDI** AND ITS **EMPLOYABILITY**. This is aimed at increasing the training capacities in RDI of the System, encouraging job placement and the employability of trained resources, both in the public and business sectors, and facilitating their temporary mobility among the public institutions and between these and the private sector for the implementation of RDI activities.
2. The PROMOTION OF **SCIENTIFIC AND TECHNICAL RESEARCH OF EXCELLENCE**. This aims to promote the generation of knowledge, increase the scientific leadership of the country and its institutions and to encourage the generation of new opportunities which may trigger the future development of highly competitive technological and business capacities.

3. The PROMOTION OF **BUSINESS LEADERSHIP** IN **RDI**. The objective is to increase the competitiveness of the production network by increasing RDI activities in all areas and, particularly, in those sectors which are strategic for growth and the creation of jobs in the Spanish economy and the Autonomous Regions.
4. The PROMOTION OF **RDI** ACTIVITIES **AIMED** AT ADDRESSING **GLOBAL SOCIETAL CHALLENGES**, and in particular at those affecting the Spanish society. This objective addresses the need to encourage the scientific and innovative potential of the country towards areas which respond to the numerous problems faced by our society and which require major effort as regards RDI. These challenges, given their nature and complexity, require that the generation of new knowledge be combined with its application to technologies, products and services that may in the future contribute to the scientific, technological and business leadership of the country.

The deployment of the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION, the impact of its actions resulting and the achievement of the proposed objectives depend in turn, on a set of measures linked to the characteristics of the environment in which the stakeholders are required to conduct their activities. Thus, **SIX PRIORITY LINES** have been identified. These will enable the foundations for future economic development and the prosperity of our society to be laid, and shall be sustained by our collective capacity to innovate. These lines of action, which are transversal in nature and consequently affect the general established objectives, are as follows:

I. The creation of a **FAVOURABLE ENVIRONMENT** to enable the development of RDI activities and a flexible and efficient framework adapted to the needs of the stakeholders, in the area of both public and business R&D.
II. **SPECIALISATION AND AGGREGATION IN THE GENERATION OF KNOWLEDGE AND TALENT** to lead to the scientific and technological specialisation of the stakeholders in the System, including institutions, centres, companies, groups and human resources. In addition, the aggregation of capacities, together with the scientific and technical specialisation of the implementing stakeholders, allows the strengths and potential for excellence of each of the stakeholders in the System to be identified and leveraged and the critical mass required for international leadership to be attained.
III. The stimulation of the **TRANSFER AND MANAGEMENT OF KNOWLEDGE** in open and flexible RDI collaboration environments in which interaction, the diffusion of ideas and the adoption of shared models and objectives favour the development of new ideas and encourages their transfer to new commercial and non-commercial applications, thereby improving the results obtained.
IV. Support of for the **INTERNATIONALISATION** and promotion of the **INTERNATIONAL LEADERSHIP** of the *Spanish Science, Technology and Innovation System*, as this is an evident competitiveness and differentiation factor that it is essential to promote.
V. The creation of a highly competitive regional framework based on **SMART REGIONAL SPECIALISATION** to provide the backbone in the different Autonomous Regions to the social and economic development that requires convergence based on the capacities of the existing production network, the scientific potential of the stakeholders and the boost to innovation as a driver of change and progress.
VI. The diffusion of a **SCIENTIFIC, INNOVATIVE AND ENTREPRENEURIAL CULTURE**, one that pervades society, fosters creativity and achieves a greater degree of social and institutional acceptance of the endeavour.

Lastly, the mechanisms included address the adoption of management principles and instruments to work in coordination in Public Administration actions. These include:

a) The CO-RESPONSIBILITY OF ALL THE PUBLIC ADMINISTRATIONS in attaining the objectives and commitment to the established priorities, including the implementation of joint programming and co-financing

instruments among the Administrations, in order to develop and consolidate the capacities of the System and the scientific, technological and business leadership of their stakeholders, together with the co-financing of Singular Scientific and Technical Infrastructures, based on scenarios that are in line with the level of scientific and technological evolution and the established borrowing capacities.

b) The promotion of OPEN ACCESS to publications and the results of research financed with public funds.
c) The setting up of an INTEGRATED INFORMATION SYSTEM and the improvement of the quality of indicators for monitoring the actions funded by the Public Administrations and their impact.
d) ADMINISTRATIVE SIMPLIFICATION and streamlining of public measures and the adoption of procedures and instruments based on simple, flexible, dynamic schemes to gradually reduce the transaction costs borne by the stakeholders, by paying for communication and interaction with the latter.
e) The HARMONISATION OF EVALUATION CRITERIA AND PRACTICES, both *ex ante* and *ex post*, which are enshrined in the best international practices to ensure competence among the stakeholders in the allocation of public resources and the promotion of funding by results, including firm support for evaluation practices involving independent international experts.
f) Measures, reforms and the design of instruments to capture PRIVATE FUNDING for scientific and technical research and innovation, and the attraction of investment in R&D from abroad and from foreign companies.

The SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION (2013-2020) presents the conceptual framework for the design of RDI policies in Spain, the specific measures of which are the object of development and are implemented in the corresponding scientific and technical research and innovation plans.

In addition, in line with its structure and content, the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION aims to cross the boundaries existing between scientific research, development and innovation, many of which are the result of an artificial confrontation and differentiation due to the nature of the stakeholders responsible for the implementation of the different RDI activities. The STRATEGY addresses innovation at all levels and includes, therefore, all stakeholders who share the responsibility to innovate and its momentum, to promote education, boost technological modernisation, scientific research, industrial development, infrastructures, etc. This shared vision is essential for transforming a society which must develop in an environment of increasing complexity, uncertainty and competitiveness.

2. BACKGROUND AND JUSTIFICATION

Scientific and technical research and the development of innovation are factors which are vital for the economic growth of a country and are the basis for its progress and social welfare. Therefore, since the end of the nineties, in view of the competitiveness gap, RDI policies have occupied an important place on the European Union agenda and are considered as a key factor for the creation of employment and long-term growth, the improvement of competitiveness and productivity and for addressing international challenges.

In 2010, the *European Strategy 2020* established five key objectives that must be met in the areas of employment, education, research and innovation, social integration and the reduction of poverty and climate change and energy, and included seven flagship initiatives for addressing the social challenges faced by the EU: a digital agenda for Europe, Innovation union, youth on the move, a resource-efficient Europe, an industrial policy for the globalisation era, an agenda for new skills and jobs and the European platform against poverty.

In Spain, the *National Strategy* on *Science and Technology* approved in 2007, and effective until 2015, provides the strategic framework in terms of RDI. Its objectives are: (1) to position Spain at the forefront of knowledge; (2) to promote a highly competitive business network; (3) to achieve the integration of regional areas in the Science and Technology System; (4) to promote the international dimension of the Science and Technology

System; (5) to construct a favourable environment for investment in RDI and (6) to provide good conditions for the diffusion of science, technology and innovation. Furthermore, halfway through 2010, and in line with the *Innovation Union*, the General Administration of the State approved the *National Strategy on Innovation* (e*2i*), in which five priority lines of action were defined: (1) the creation of a favourable environment for innovation; (2) the promotion of innovation from public demand; (3) international projection; (4) the strengthening of territorial cooperation, and (5) human capital, placing the transfer of knowledge in the centre of these lines.

The SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION 2013-2020 replaces the above two documents, after reviewing and analysing the degree to which the established objectives were attained and the efficiency of the instruments designed for this purpose, and confirming that the results were noticeably different to those initially forecast in the *National Strategy on Science and Technology* and in the *State Strategy on Innovation*.

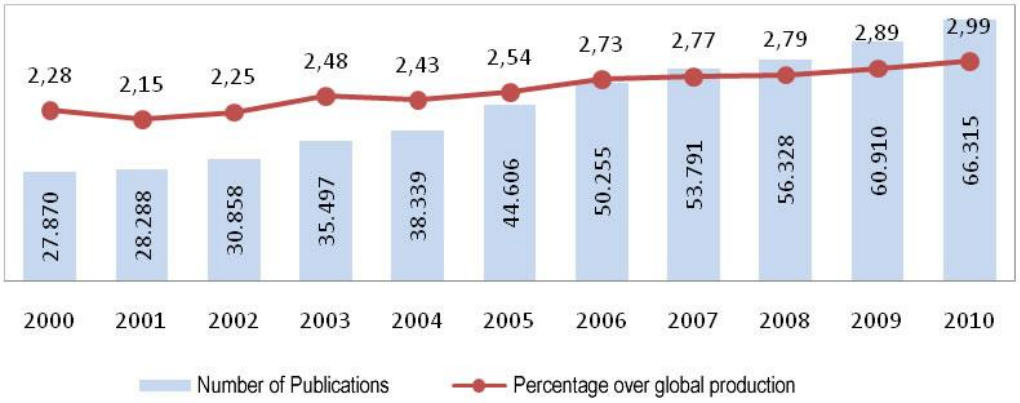
This is why the Government's *National Reform Programme* for 2012 refers to the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION as an instrument for "boosting economic growth and competitiveness in the country". In addition, the SPANISH STRATEGY, in line with the more recent initiatives of neighbouring countries, highlights that RDI policies should be directed towards the creation of capacities and, above all, to the attainment of results to speed up the social and economic impact of these activities.

3. DESCRIPTION OF THE SPANISH SCIENCE, TECHNOLOGY AND INNOVATION SYSTEM

The recent evolution of the main indicators of the *Spanish Science, Technology and Innovation System* may be consulted at HTTP://ICONO.FECYT.ES/. This shows the changes recorded in recent decades, in particular the following aspects:

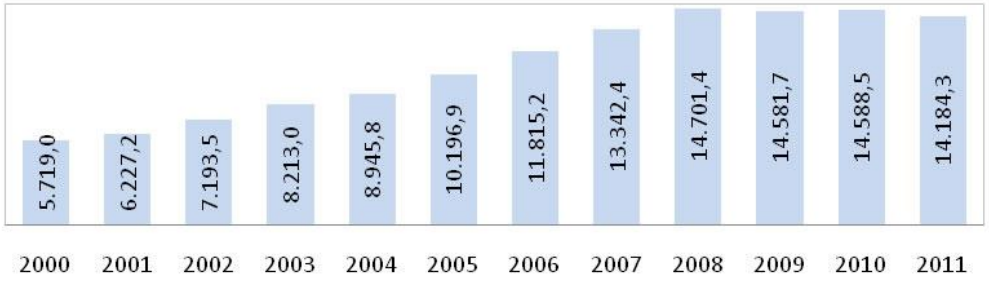
1. The growth recorded with respect to scientific production together with improvement in quality and the international impact of the latter (Figure 1).
2. The increase recorded since the end of the nineties in the resources allocated to funding RDI (Figure 2), and the growth in the number of human resources working in R&D (Figure 3).
3. The international opening of the System, reflected in the participation of researchers and companies in international projects and programmes, especially the EU 7th Framework Programme (Figure 4), and in the adaptation of PhD training programmes to the European Higher Education Area.
4. The creation of new research and technology development centres, the recognition of campuses and centres of excellence and the consolidation throughout the country of new spaces for innovation, especially around science and technology parks, together with the promotion of Technology Platforms and Alliances for Science and Innovation directed at stimulating collaboration among public and private stakeholders and companies
5. The deployment of the «Map of Singular Scientific and Technical Infrastructures (ICTs)», which is key to the territorial development of the *Spanish Science, Technology and Innovation System*, together with its integration in the European Research Area.

Figure 1 Spanish scientific production (number of documents and percentage of global total). 2000-2010



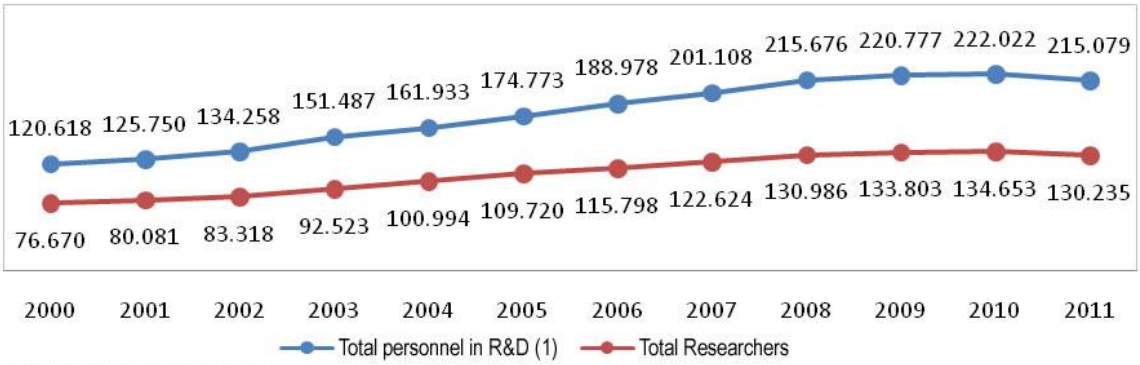
Source: SCImago Journal and Country Rank (consulted in November 2012) from Scopus data, 2000-2010.
Prepared by FECYT

Figure 2 Total internal expenditure on R&D in thousands of Euros. 2000-2011



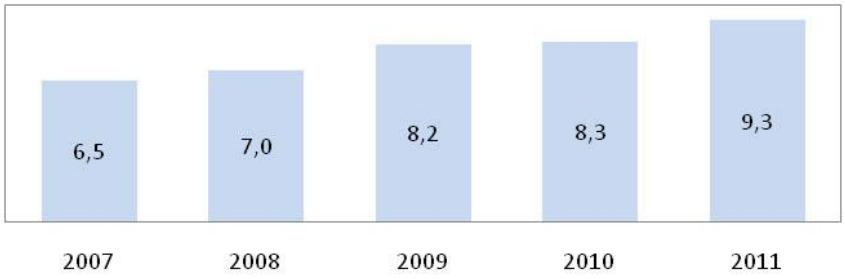
Source: INE, Prepared by FEYCT.

Figure 3 Personnel employed in R&D (in FTE). 2000-2011



Note: FTE Full-time Equivalent
(1) Includes research, technical and auxiliary personnel.
Source: INE. Prepared by FEYCT.

Figure 4 Return of Spanish participation in the European Union 7th Framework Programme (percentage of total). 2007-2011

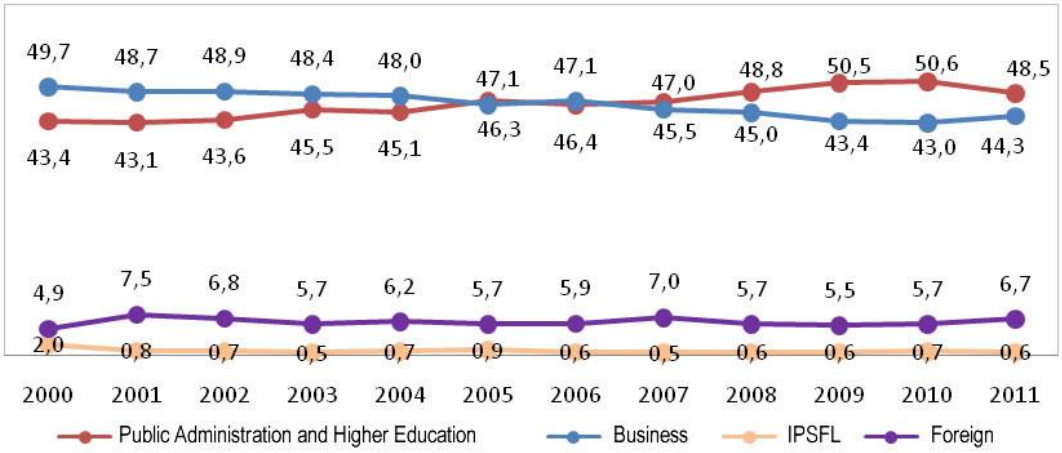


Source: CDTI and CIEMAT (Consulted in May 2012). Prepared by FEYCT.

Nevertheless, and in spite of the above advances, the *Spanish Science, Technology and Innovation System* is also characterised by:

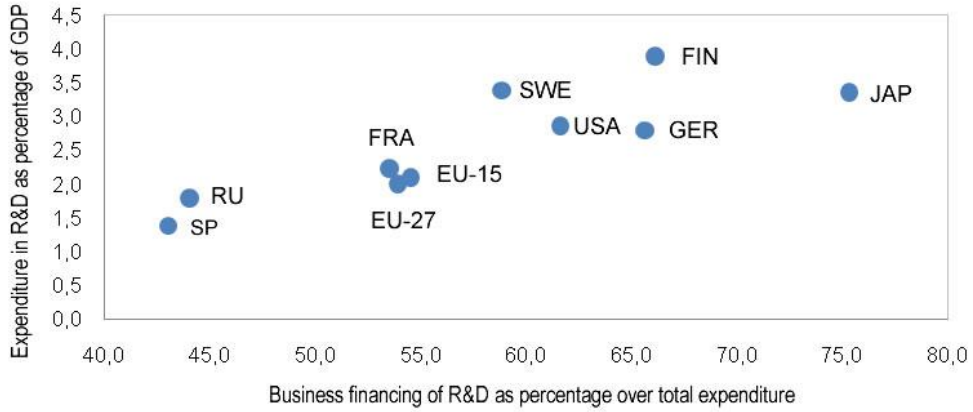
6. A lower percentage expenditure on R&D, which continues to be lower than that of neighbouring countries, in spite of the implementation of new public-private collaboration instruments and the existence of a favourable fiscal framework for RDI (Figures 5 and 6). The persistence of this gap results in the low innovative capacity of the country (Figure 7) in clear contrast to the scientific capacities developed.
7. The low number of innovative companies, especially SMEs, and the limited weight of medium/high technology sectors (Figures 8 and 9), in addition to the fact that the companies that do systematically conduct R&D activities are fewer than is desirable (Figure 10).
8. Closely linked to the above aspects, and although the percentage of researchers in relation to the employed population in Spain has experienced a significant growth (Figure 11), the number of researchers in business remains at levels which are clearly inadequate for boosting technological leadership and the innovation capacities of the production network.
9. The persistence of major regional disparities with respect to effort and investment in RDI (Figure 12).

Figure 5 Internal expenditure on R&D by origin of funds (as a percentage of the total). 2000-2011



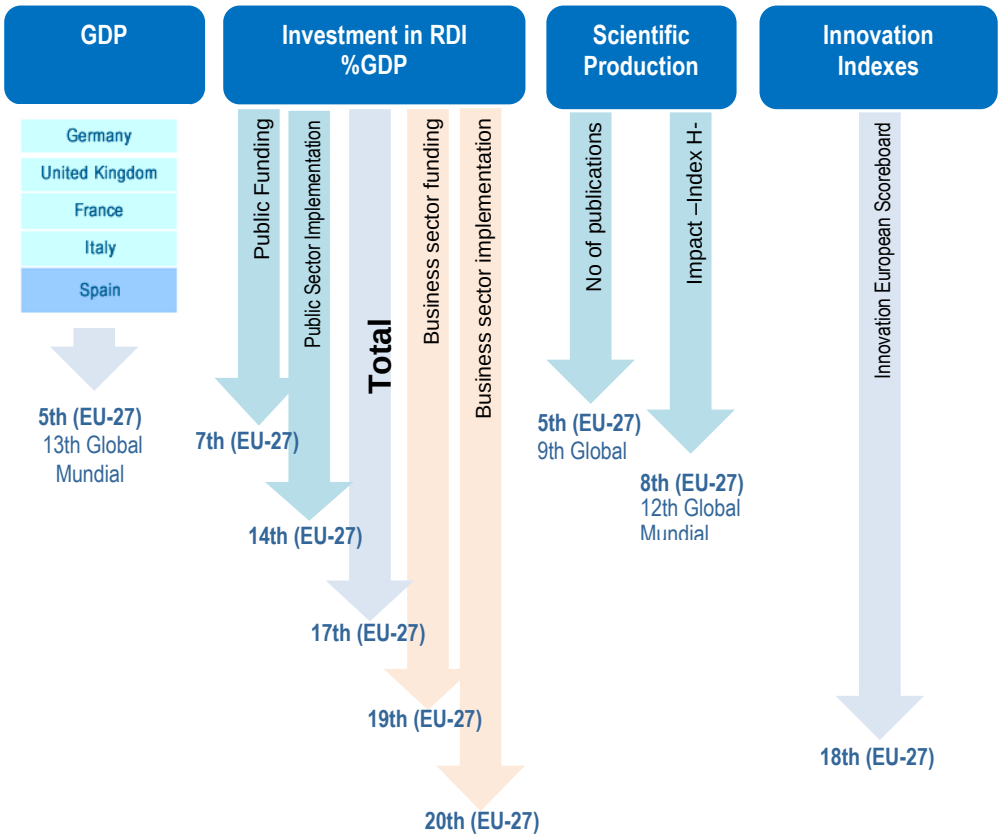
Source: INE. Prepared by FEYCT.

Figure 6 Relation between expenditure on R&D as a percentage of GDP and the weight of business funding of R&D. 2010



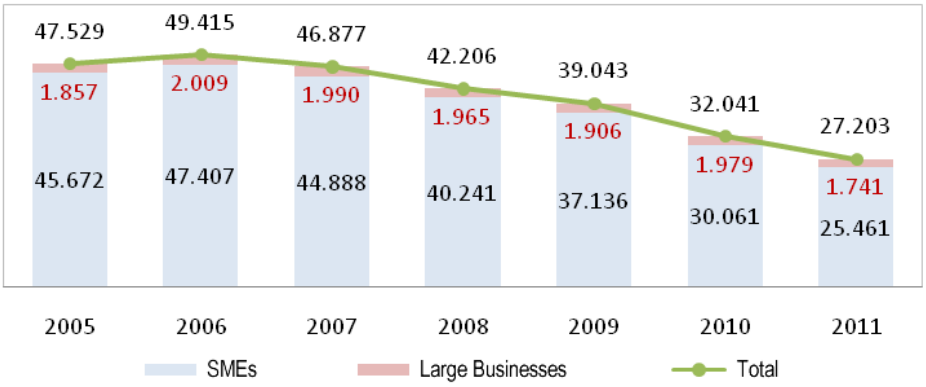
Source: Eurostat, 2010 data (for Sweden, the United States and Japan, data from 2009). Prepared by FEYCT.

Figure 7 Relative position of Spain on an international level



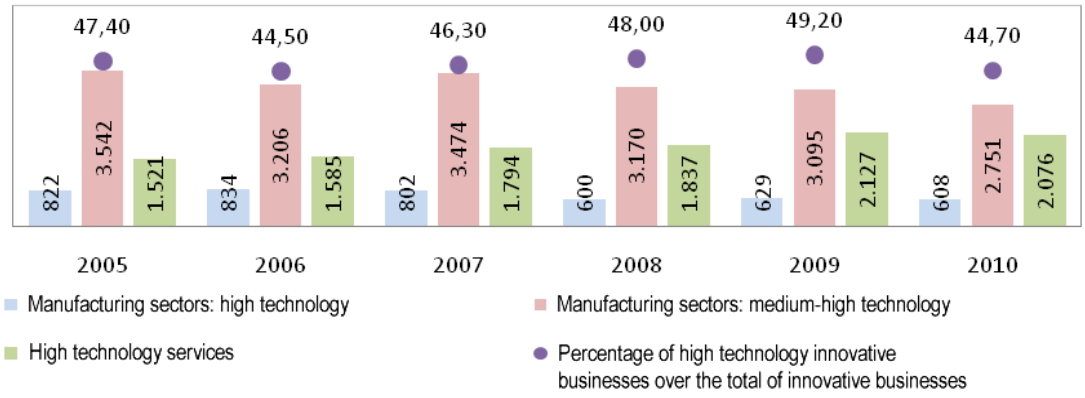
Source: Author

Figure 8 Technologically innovative companies by size of company. 2005-2010



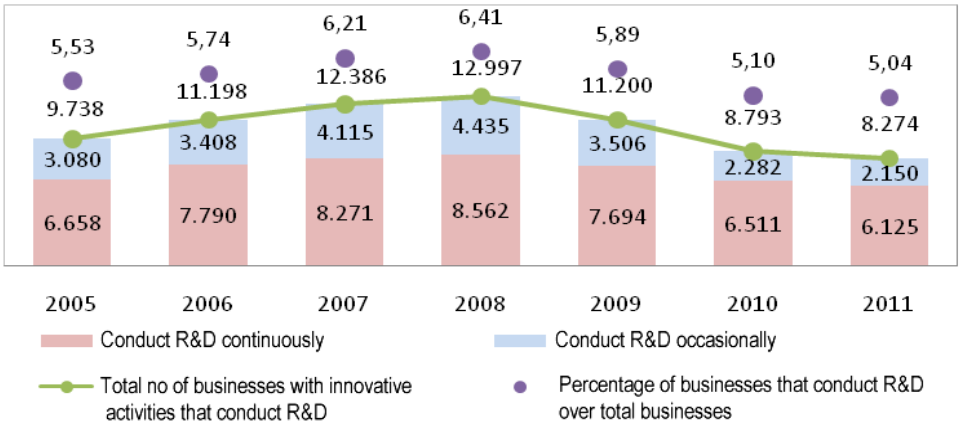
Source: INE. Prepared by FEYCT.

Figure 9 Innovative companies in high technology sectors (number and percentage of total number of innovative companies). 2005-2011



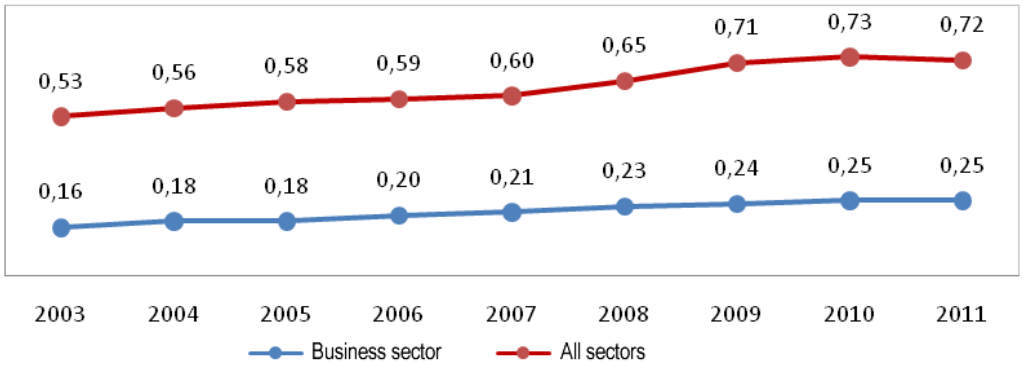
Source: INE. Prepared by FECYT.

Figure 10 Companies with technological innovation activities that carry out R&D (number and percentage of total). 2005-2011



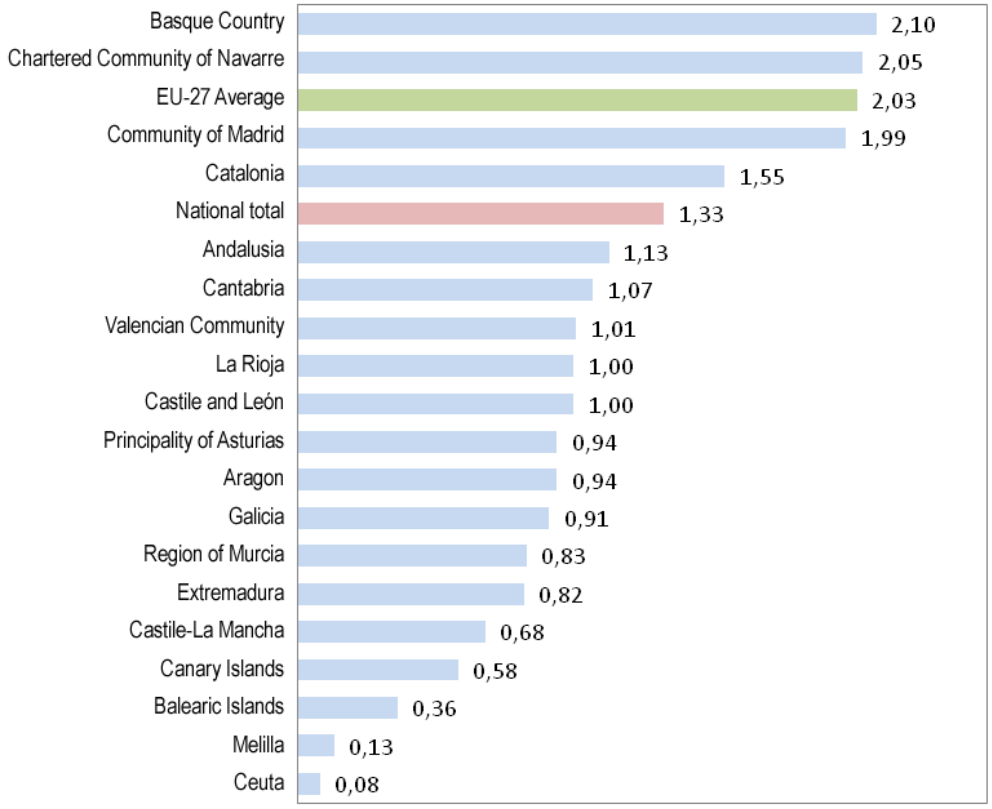
Source: INE. Prepared by FECYT.

Figure 11 FTE researchers in relation to employed population (percentage of total). 2003-2011



Note: FTE Full-time equivalent
Source: Eurostat. Prepared by FEYCT.

Figure 12 Total internal expenditure on R&D by autonomous region (percentage of regional GDP). 2011



Source: INE. Prepared by FEYCT.

The characteristics of the *Spanish Science, Technology and Innovation System* expressed in terms of strengths, weaknesses, benefits and opportunities, which have been used to define the objectives and priority lines of action for the **SPANISH STRATEGY ON SCIENCE AND TECHNOLOGY AND ON INNOVATION**, are shown below (Figure 13):

Figure 13 SWOT analysis of the Spanish Science, Technology and Innovation System

Sustainability and the future development of the *Spanish Science, Technology and Innovation System* must be tackled in a context marked by the reduction in investment in RDI by both Public Administrations and the business sector since 2010. Consequently the achievement of the objectives established in the STRATEGY requires measures and instruments aimed at improving the resource and results efficiency, at promoting the participation of the business sector in the RDI funding and at making the generation and use of scientific and technical knowledge and innovation crucial for future social and economic development of the country. To do so, it is necessary to implement the reforms aimed at increasing the impact of the results of RDI activities, including legislative, administrative, regulatory and financial measures which must be introduced to provide the System with greater flexibility and efficiency.

4. OBJECTIVES

The **GENERAL OBJECTIVES** represent the goal to be reached in the 2013-2020 period, and as such they are quantifiable and therefore accompanied by the corresponding effort and results indicators.

The four general objectives of the SPANISH STRATEGY mentioned above are broken down into a total of **18** specific objectives, the definition of which has taken into account the characteristics and diagnosis of the *Spanish Science, Technology and Innovation System.* In its basic conceptual design, the STRATEGY uses a matrix structure (Table 1) which enables, as a result of the intersection between objectives and priority lines of action, some of the main areas of action to be developed in the corresponding scientific and technical research and innovation plans to be identified, or which will make up the «roadmap» of the actions in RDI policies that the Administrations involved in the preparation of the Strategy undertake to carry out during the effective period of the latter.

Table 1 Structure of the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION

OBJECTIVES	PRIORITY LINES OF ACTION					
	1. DEVELOPMENT OF A RDI FRIENDLY ENVIRONMENT	2. PROMOTION OF THE GENERATION OF KNWLEDGE AND TALENT	3. TRANSFERAND MANAGEMENT OF KNOWLEDGE	4. INNOATIVE AND COMPETITIVE REGIONS	5. INTERNATIONALISATION	6. SCIENTIFIC, INNOVATIVE AND ENTREPRENEURIAL CULTURE
I. RECOGNITION AND PROMOTION OF TALENT AND ITS EMPLOYABILITY						
1. TRAINING AND QUALIFICATIONS IN RDI						
2. MOBILITY AND DEVELOPMENT OF RESEARCH CAREER						
3. INCLUSION OF HUMAN RESOURCES IN RDI						
II. PROMOTION OF SCIENTIIFIC AD TECHNICAL RESEARCH OF EXCELLENCE						
4. GENERATION OF FRONTIER KNOWLEDGE						
5. DEVELOPMENT OF EMERGING TECHNOLOGIES						
6. INSTITUTIONAL REINFORCEMENT						
7. CONSOLIDATION AND USES OF SINGULAR SCIENTIFIC AND TECHNICAL INFRASTRUCTURES						

III. FOSTERING BUSINESS LEADERSHIP IN RDI						
8. BOOSTING BUSINESS ACTIVITIES IN RDI						
9. ESSENTIAL ENABLING TECHNOLOGIES						
10. COLLABORATIVE RDI AIMED AT PRODUCTION NETWORK						
IV. RESEARCH AIMED AT SOCIETAL CHALENGES						
11. HEALTH, DEMOGRAPHIC CHANGE AND WELFARE						
12. FOOD SAFETY AND QUALITY, PRODUCTIVE AND SUSTAINABLE AGRICULTURE, SUSTAINABILITY OF NATURAL RESOURCES, MARINE, MARITIME AND INLAND WATERWAY RESEARCH						
13. ENERGY, SAFETY AND SAFE, SUSTAINABLE AND EFFICIENT ENERGY MODELS						
14. SMART, SUSTAINABLE AND INTEGRATED TRANSPORT						
15. ACTION ON CLIMATE, RAW MATERIAL AND RESOURCE EFFICIENCY						
16. SOCIAL INNOVATIONS AND CHANGES						
17. ECONOMY AND DIGITAL SOCIETY						
18. PUBLIC SAFETY, PROTECTION OF FREEDOM AMD RIGHTS						

The justification for and description of the objectives of the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION is outlined below.

4.1. FOSTERING AND PROMOTING TALENT AND ITS EMPLOYABILITY

In accordance with the *European Charter for Researchers* (2005/251/EC), the availability of human capital in R&D is essential for competitiveness in Europe. The training of human resources, especially those dedicated to RDI, has a close relationship with the innovation capacity of the institutions and organisations in which these activities take place. A base of well-trained and highly qualified workers is necessary not only for the generation of new knowledge and technologies but also for their adaptation, transformation and exploitation, and for the stimulation and introduction of new models and new organisational principles.

Therefore, and although Spain has a critical base of PhDs and researchers, it is essential to promote their inclusion, both in the public and private sectors, by improving conditions to achieve greater absorption by the *System*.

Integration into the labour market, and especially the employability of PhDs, researchers, technicians and personnel dedicated to RDI, is one of the essential objectives of the SPANISH STRATEGY. To achieve this it is necessary to work on the definition of the career of the researcher, principally in the public sector, to provide for the research requirements of universities, public research bodies and public R&D centres in Spain. This is without forgetting that the correct development of the researcher's career must include measures that recognise and increase the temporary mobility of university lecturers and researchers, as well as other RDI personnel, in the private and public sector. Mobility is critical for enhancing the transfer of knowledge, improving the capacities of businesses for absorbing knowledge and technologies, especially of SMEs, and for stimulating dialogue and collaboration among the stakeholders of the System.

Lastly, the Spanish Strategy is not unaware of the intense international competition faced by Spain for best researchers and technologists, creating a significant imbalance in the short-term. This situation will be addressed to prevent a net loss of human capital in the medium term.

Consequently, the specific objectives considered are as follows:

- To promote the TRAINING AND UPSKILLING of human resources that perform RDI activities
- To stimulate MOBILITY and develop the CAREER OF RESEARCHERS
- To encourage the INCLUSION OF HUMAN RESOURCES trained in RDI

4.1.1. To promote the TRAINING AND UPSKILLING of human resources to perform RDI activities

In the last ten years the number of PhD graduates, researchers and technical personnel dedicated to RDI has increased in Spain by 65 % as a result of the growth recorded in universities and public research bodies and also in business. Nonetheless, the ratio of these values in relation to the total employed population continues to be below the average of neighbouring countries. As stated in the section on the characterisation of the System, this is essentially due to the low employment rates in business. This in turn is closely linked to the limited tendency to innovate demonstrated by the business network in Spain.

Similarly, there has been a gradual widening of the gap between the number of trained PhD graduates, their scientific and technical profiles and the absorption capacities of the *System,* thus requiring greater coordination between the pre- and post-doctoral training programme and the demands for researchers and technologists in the public and private sector.

In addition, the stimulus in training for RDI development will include the extension of university training by incorporating the establishment of «industrial doctorates» as a result of collaboration between universities and businesses, who will share responsibility for supervising candidate theses, thus making their integration in the labour market easier.

Therefore, innovation not only requires a solid base of researchers, scientists and technologists, it is also necessary to promote creativity in all the training cycles, encouraging training to improve the entrepreneurship and managerial skills of our students, and of all the personnel involved in RDI. Consequently, training technical personnel to support and manage RDI activities becomes a priority for the *Spanish Science, Technology and Innovation System,* which must take on the specialisation in the profiles of graduates, post graduates and diploma students from Vocational Training Programmes, including the Dual Vocational Training Programme.

The universities, research organisations and R&D centres have to compete for the best talent. To do so, they will design a pre- and post-doctoral training programme which is highly competitive at international level. At the same time they will encourage the acquisition of training abroad, especially post-doctoral training, and the design of efficient mechanisms for the incorporation of human resources, trained and financed with public funds.

4.1.2. To stimulate MOBILITY and develop the CAREER OF RESEARCHERS

The mobility of PhD graduates, technologists and R&D personnel between public institutions and between these and the business sector is a key factor for improving the skills of the *System* and is an essential vehicle for: (1) establishing partnerships, (2) enabling learning processes, (3) increasing the use of scientific and technological knowledge and (4) the generation of new knowledge, new applications and the development of products and services. In this context, the SPANISH STRATEGY establishes among its specific objectives the elimination of barriers to mobility and the definition of flexible programmes for the assessment and recognition of RDI activities, both in the public and private sectors, without this becoming a barrier for the development and promotion of professionals, by combining the possibility of temporary posts for lecturers, researchers, technologists and R&D personnel, from universities and public research bodies at private R&D centres and businesses.

International mobility throughout the career of a researcher represents a fundamental objective of the SPANISH STRATEGY for guaranteeing good professional growth of lecturers, researchers and R&D personnel who carry out their activities in the System.

Moreover, the development of the career of the researcher in Spain includes, together with mobility, the capture of talent and, therefore, its contracting and inclusion in the *Spanish, Science, Technology and Innovation System* from a predictable and suitable framework to enable trained young people to embark on their work in the System. In addition, the career of researcher includes the setting up of the contractual figures established in the *Law on Science, Technology and Innovation,* which will increase access to better trained human resources, using selection policies based on merit and which are internationally recognised, supporting contracting and the capture of talent at international level, requiring the administrative and legal barriers that hinder the incorporation of scientists from outside the Community to be reduced.

4.1.3. To encourage THE INCLUSION AND EMPLOYABILITY of human resources trained in RDI

Accumulated evidence on the initiatives undertaken by the different Administrations to promote the incorporation of RDI personnel, especially PhD graduates, shows that they have been a major incentive for attracting talent to our universities and public organisations as well as stimulating the demand for technology and the innovative capacity of the businesses that have taken part in the existing programmes. In this respect, measures have been established to promote the incorporation and employability of PhD graduates, technologists, technicians and other RDI personnel, in the research centres, universities, R&D centres and businesses.

Nevertheless, Public Administrations activities as regards the incorporation of human resources in RDI, must be accompanied by a strict evaluation process to guarantee the suitability of the individuals employed in the private sector and, even more so, in the public sector. The stable incorporation of RDI personnel in the public university sector should consider the requirements, objectives and strategies defined by the centres in terms of research, development and innovation, and not only respond to the logical educational requirements of the centres.

To promote the employability of future generations, special attention will be given to curricular design at all levels of education in order to foster creativity, entrepreneurship and training in scientific and technical skills and directives in line with section 4.1.1, and mobility during the stages of training will be reinforced.

Investment in training, the development of the career of researchers and the promotion of mobility must allow the System to capitalise on the efforts made and to increase the scientific, technological and innovative potential, as it is essential to increase the incorporation of personnel dedicated to RDI.

4.2. Promotion of SCIENTIFIC AND TECHNICAL RESEARCH OF EXCELLENCE

Basic scientific and technical research is not only essential for knowledge evolution but, even while acknowledging that innovation is not the final, certain and necessary result of scientific research, it forms the basis for future applications and innovations. In this respect, scientific and technical research is a vital activity for the prosperity of a society based on knowledge, even though the «idea to market» path is uncertain and complex.

The diagnosis of the *Spanish Science, Technology and Innovation System* reveals the efforts of researchers to generate knowledge: scientific production exceeds 3 % of global scientific production, in addition to the growing international leadership of science generated in Spain, even though notable differences still remain. Furthermore, global competitiveness in the generation of scientific knowledge, together with the high scientific growth rates displayed by emerging countries, is forcing us to raise the quality and international impact of the

scientific and technical research conducted in Spain. It is essential for the *Spanish System* to have institutions, centres and groups of excellence at world level in a position to contribute to the generation and exploitation of frontier knowledge. It must be remembered that scientific and technical research of excellence must have the support of an advanced network of infrastructures and scientific and technical equipment, and have access to top level international infrastructures, as is the case of the Singular Scientific and Technical Infrastructures (ICTS).

The backing of scientific and technical research institutions, centres and groups of international prestige is crucial for the evolution of the *Spanish Science, Technology and Innovation System* and for the future social and economic development of the country. Therefore, together with the direct measures proposed to promote the generation of knowledge, the necessary transformations relating to the governance of universities and public research bodies shall be addressed in order to increase the level of international scientific leadership and remove legislative, administrative and managerial barriers that currently hinder the adoption of more flexible, efficient and competitive models aimed at increasing the scientific and social impact of the results of research.

In order to achieve this objective, the initiatives headed by the *European Research Council* (ERC) to promote scientific and technological excellence at European level shall be strengthened. These initiatives are a fundamental framework of reference in the activities to be developed as part of the SPANISH STRATEGY in relation to the promotion of scientific and technical research of excellence.

The evaluation and selection processes applied to public actions designed to promote scientific and technical research of excellence shall be strict, transparent and equivalent to the best international practices.

The specific objectives are as follows:

- The generation of **FRONTIER KNOWLEDGE**
- The development of **CUTTING EDGE AND EMERGING TECHNOLOGIES**
- The strengthening of R&D **INSTITUTIONS**
- The consolidation and uses of **SINGULAR SCIENTIFIC AND TECHNOLOGICAL STRUCTURES**

4.2.1. The generation of FRONTIER KNOWLEDGE

The accelerated process of knowledge generation registered in recent decades, combined with the development and application of powerful infrastructures and technologies for research, has allowed us to witness a high number of scientific advances that have altered our way of life and consumer habits. Many of these advances have helped and will help to obtain new applications and the adoption of more efficient solutions until now considered unviable.

Intense global competition in terms of knowledge and talent, as mentioned above, likewise leads to the need to encourage top level research with an international impact in the so-called «frontier of knowledge», as this makes it possible to identify long-term opportunities for innovation capable of generating competitive advantages by the stakeholders responsible for its development. Increasingly, research at the «frontier of knowledge» represents a dynamic space that frequently takes place beyond the traditional disciplinary limits that permit the recognition of new long-term opportunities for innovation. Thus, the promotion of scientific and technical research at the «frontier of knowledge», which concentrates efforts in emerging areas based on interdisciplinary and converging approximations, has a leading position in the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION, highlighting collaboration among research groups and between the public and private sector.

Action in this area will reflect firm commitment to research, human resources, projects and infrastructures, the results of which represent significant qualitative advances in science and, in the medium and long term, will help to improve the international impact of our institutions, centres, research groups and researchers, with special attention to the activities carried out in the public sector. Although the scientific and technical research carried out in universities and public research centres is not the only source for the generation of innovations, it is undoubtedly an essential part of the development of the «innovative ecosystem» sought by the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION, as these stakeholders are responsible for the implementation of 47.7 % of the investment in R&D recorded in 2011.

4.2.2. The development of CUTTING EDGE AND EMERGING TECHNOLOGIES

The promotion of scientific and technical research at the «frontier of knowledge» is linked to the introduction of radical advances and disruptive models which affect both research methodologies and theoretical models and the development of cutting edge and emerging technologies. Therefore, they cannot be considered as an isolated area in the above objectives as they are the result of an ongoing process of exploration that is at the base of scientific activity.

The potential for transforming the production model and the lifestyle of society, and for introducing the major qualitative leap that the *Spanish Science, Technology and Innovation System* requires, is linked to the exploitation of opportunities that may arise form new technological advances of a disruptive nature, and which, therefore, are characterised by a high level of uncertainty with respect to the industrial feasibility of the proposed alternatives and by the instability of the technological standards and paths. In as much as they are key developments for the technological leadership of a country in the medium and long term, emerging and cutting edge technologies are born in highly competitive environments in which their diffusion and adoption by potential users is a critical factor. Therefore, the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION will mobilise the development of exploratory and pre-competitive initiatives which seek new opportunities on a small scale that are scalable in the future, of interest industrially, that have an impact on the evolution of future technological paths and which promote the capacities of leadership in sectors which are essential for the Spanish economy.

4.2.3. The strengthening of R&D INSTITUTIONS

In the last thirty years, the development of scientific and technical research in Spain has relied on research groups of varying sizes and permitted the exploitation of existing talent, particularly in the public sector. Nevertheless, the competitiveness and scientific leadership of the *Spanish Science, Technology and Innovation System* depends on the size of the scientific and technological community and, more notably, the characteristics of the institutions in which the research activities are carried out, which have to attract talent and public and private investment, in competition with the best international centres.

The promotion of scientific and technical research of excellence therefore requires institutions (universities, public research bodies and public R&D centres) which are well governed, able to exercise scientific leadership at international level in the respective areas of specialisation and which, moreover, as part of their own strategy, share a clear innovative calling, reflected in the capacity to generate companies with a technological base, and the inclusion of national and international talent, and which promote collaboration among all the stakeholders in the System.

Therefore, in the next few years, public RDI policies must encourage the international recognition of R&D institutions. With this in mind they shall address the essential actions that define highly competitive RDI programmes and strategies, to attract resources and increase the research potential of Spanish institutions at global level, involving the improvement and definition of the model of governance of the R&D institutions to

provide them with the flexibility, autonomy and accountability required for their reinforcement. In addition, the General State Administration and the Autonomous Regions shall jointly establish the measures to consolidate the centres and units with the recognition and support of their RDI activities with international leadership capacities and potential.

Finally, to facilitate and accelerate the transfer of the R&D results applied to products and services to improve the competitiveness of the Spanish economy, the existence of stakeholders able to facilitate the transfer processes is essential. This requires the adoption of measures to promote the institutions dedicated to these activities, in particular the Technology Centres and Centres for the Support of Technological Innovation, Science and Technology Parks and the technology transfer units.

4.2.4. The consolidation and uses of SINGULAR SCIENTIFIC AND TECHNOLOGICAL STRUCTURES

Access to advanced scientific and technological infrastructures is one of the most important assets for maintaining leadership in research, increasing the specialised training capacity in RDI activities and capturing talent. The progress seen in Spain has been significant and this is reflected in the current «National Map of Scientific and Technological Infrastructures», which represents a key measure for the territorial development of the *Spanish Science, Technology and Innovation System,* by defining its profiles of scientific and technical specialisation and facilitating its integration in the *European Research Area*.

Furthermore, the achievement of new initiatives and the consolidation of those already operating must be re-examined with sustainability criteria, according to the viability of their scientific and technological base and, at the same time, guaranteeing that a programme for use is defined that ensures an efficient provision of services to all potential users (scientific, technological and industrial, national and international), paying special attention to the opening of these initiatives to the demands of the business sector and to the associated industrial and technological return. At this point, the SPANISH STRATEGY includes the update of the «National Map of Singular Scientific and Technical Infrastructures (ICTS)» for 2013-2016 and 2016-2020, which will be approved by the Science, Technology and Innovation Policy Council, as a long-term tool for the planning and development of these infrastructures in coordination with the Autonomous Regions.

The opening of large scientific infrastructures, essential for the advance of cutting edge science and technology at global level, is a significant effort in the sphere of international collaboration. This is and will be reflected by Spain's participation in the European Strategy Forum on Research Infrastructures (ESFRI), in which Spain will contribute to defining the best policies and instruments for developing and supporting those of pan-European interest which most contribute to the construction of the European Research Area. The SPANISH STRATEGY will also sponsor the active participation of the stakeholders of the Spanish System in the construction and operation of these installations, including specific measures to support the "science industry".

4.3. BOOSTING BUSINESS LEADERSHIP IN RDI

Spain's production network is characterised, among other aspects, by: (a) the significant predomination of SMEs; (b) a strong presence of traditional sectors with a low level of inclusion of R&D in their processes and products, and similarly for the non-industrial activities as is to be expected for an essentially service economy and, (c) an even more significant volume, in the industrial sector, of activities directed at manufacture, particularly of production equipment.

In spite of the limitations imposed by these characteristics, in recent decades Spanish businesses have acquired international leadership skills thanks to the introduction of multiple technological and non-technological innovations. Nonetheless, global competitive pressure, the decline of the Spanish economy and the negative evolution of the indicators linked to effort and investment in business RDI indicates that the future growth of the

Spanish economy and of employment is directly associated to the capacity of businesses, especially SMEs, to innovate. These should grow in size and technological and commercial ambition and include innovation as an essential part of their business model.

In order to do so, in addition to the promotion of business R&D, technological innovation and the promotion of the inclusion of enabling technologies of a horizontal nature, it is necessary to encourage the development of new manufacturing and design technologies; reduce existing barriers to innovation in the environment; promote the transfer and improve the absorption of knowledge by businesses in key sectors for our economy; introduce non-technological innovation as a key element in business leadership and encourage collaboration between the stakeholders in the System.

Similarly, innovating businesses with strong RDI capacities require access to private and public funding, accompanied by experience and know-how. At this point investment in risk capital at the early stage may play a key role. The consolidation of a risk capital ecosystem favourable to business RDI requires an increase in the specialisation of the participating stakeholders (private funds, public funds, informal investors, etc.), as well as obtaining a greater critical mass of available capital to provide, in addition to an adequate diversification for the investors, scaled support, within reach and with certain continuity at all stages of business development, from the seed capital and start-up to the subsequent rounds in successful and already consolidated companies.

The SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION recognises the need to promote the development of new technological solutions in all the key sectors for the Spanish economy with a business approach which deals with the international commercialisation of the latter in the global markets, especially in the emerging markets, and in close relation to the decisions of the economic policy and foreign trade policy, together with the rest of the sectorial policies of the Public Administrations.

Boosting business leadership in RDI involves: (i) raising levels of business investment in R&D; (ii) promoting stability and sustainability in the time of these investments; (iii) increasing the number of businesses, especially SMEs, which take part in the implementation of R&D activities and which systematically adopt innovation models to increase the efficiency and competitiveness of their manufacturing processes and the marketing of new products and services; (iv) extend the participation of Spanish businesses in the leading global networks of production and marketing, and (v) strengthen the leadership role of the large Spanish companies by providing incentives for the growth of their expenditure in R&D and supporting the localisation and development of RDI activities led by foreign companies and multinationals in Spain.

Consequently, business leadership in RDI envisages the following specific objectives:

- The driving of BUSINESS RDI ACTIVITIES as a key factor for competitiveness.
- The promotion of the ESSENTIAL ENABLING TECHNOLOGIES.
- The stimulation of COLLABORATIVE RDI AIMED AT THE DEMANDS OF THE PRODUCTION NETWORK.

4.3.1. The boosting of BUSINESS RDI ACTIVITIES

Business investment in RDI is a decisive variable in the definition of a competitive economy; it is a strategic tool for improving the competitive position of Spanish companies in the international market; it has an influence on the capacity to generate employment, and is a substantial element in the development and strengthening of relations between the stakeholders of the *System*.

Hence the objective to increase business participation, in particular of SMEs, is established in the implementation and funding of RDI and innovation activities, whether technological or not, in all areas of activity, but primarily in the aerospace, energy, ICT, chemical and pharmaceutical industries, and in traditional sectors

such as agri-food and its industry, transport, construction, tourism and leisure and cultural services, which are strategic for the Spanish economy and its regions.

Large companies, given their potential to lead business R&D as a whole, must promote their leadership role in support of the innovative capacity of the smaller companies with which they interact, in order to aid innovation in the Spanish business network. As the current expenditure on R&D of large Spanish companies is still quite small in comparison with that recorded in neighbouring countries, it is essential to stimulate growth in their levels of investment as an instrument for encouraging all business R&D and strengthening Spanish competitiveness. In this context, the SPANISH STRATEGY recognises the importance of stimulating far-reaching and ambitious business initiatives in RDI, the objective of which is business leadership in highly competitive global environments. Moreover the large companies reinforce their leadership capacity over medium and/or small companies and over the knowledge generating centres with the implementation of these initiatives.

In turn, this objective requires Public Administrations to adopt measures to: (a) enhance public-private collaboration; (b) facilitate the development of an attractive financial environment with expertise in the funding of innovation projects with high economic potential for companies; (c) create a legislative environment which favours the growth of companies at all stages in an attempt to overcome low growth rates and lack of business maturity, so that these reach a size that allows them to face the challenges of global markets; (d) create a favourable environment for inter-business cooperation to allow SMEs to join, on a larger scale, technological and non-technological innovative activities; (e) develop the capacity of the Administration to act as a driver of business innovation by managing their demand for products and services by means of innovative public purchase initiatives, and (f) support the international diffusion of Spanish technology by backing the implementation of business projects in RDI in collaboration with stakeholders from other countries and the marketing, at global level, of new products and innovative services through the corresponding promotional measures abroad.

4.3.2. The promotion of ESSENTIAL ENABLING TECHNOLOGIES

The essential enabling technologies, given their transversal nature, have a huge impact on the rest of the production network of an economy as they encourage the production capacities of the sectors of activity and contribute to improving the provision of services to the Public Administrations.

Advances in areas such as micro- and nano-electronics, photonics, nanotechnology, biotechnology, advanced materials and manufacturing systems of the future lay the foundations for future competitive advantages in a broad range of businesses and sectors, due mainly, to the horizontal nature of their applications. Information and communication technologies deserve a special mention, as they are key factors for improving the competitiveness of businesses and the efficiency of the Administrations; in addition, they represent an intensive sector in RDI.

Therefore, the SPANISH STRATEGY provides for the promotion of new advances in enabling emerging technologies with their contribution to the consolidation of the international leadership of our economy. Special attention is paid to the inclusion of these technologies in the traditional production network to encourage their use in new industrial technologies, products, services and new applications. It is essential to remember that the competitive future of a large part of the Spanish production network will depend, to a great extent, on the development and implementation of new manufacturing (and design) technologies which encourage their growth, optimise production capacities and promote a continuous technological evolution to offer products of greater added value.

4.3.3. The stimulation of COLLABORATIVE RDI AIMED AT THE DEMANDS OF THE PRODUCTION NETWORK.

Without prejudice to the implementation of measures that promote frontier knowledge, and therefore scientific and technical research of an essential nature, it is also necessary to back research which can be used by the production network in the short and medium term. Consequently, on the one hand, measures are identified and adopted to boost and promote RDI in strategic areas for Spain's industrial network and competitiveness, such as health, energy, the agri-food sector and its industry, aerospace, tourism, transport, cultural services and goods, the chemical and pharmaceutical industries and Information and Communication Technologies, and on the other hand, as part of the *Smart Specialisation Strategies* of the Autonomous Regions, a sectorial orientation at regional level will be incorporated which shall contain all the strengths of the production network existing in each one.

Convergence between the goals of research conducted in the public sector (universities, public research bodies and other public R&D centres) and the requirements of the production network, improving the latter's absorption capacities, requires a collaborative environment that will lead to the participation of stakeholders from the initial stages of the activities to be developed, an environment based on open innovation models. To achieve this objective, programmes will be rolled out to encourage the implementation of projects using public-private collaboration, the RDI stakeholders that promote the exchange of information between the participants of the public sector and the business sector will be strengthened, as these have a key role in terms of technological and prospective surveillance and the development of competitive intelligence. An exceptional feature is that the role and activities of the Technology Centres and support centres for technological innovation, technology platforms and science and technology parks, in addition to clusters and sectorial forums, will be strengthened.

Lastly, the Public Administrations must take direct action against the obstacles that currently prevent public-private collaboration in Spain; this calls for the adoption of measures and instruments aimed at raising quality and legal safety in terms of scientific collaboration and technological development, by assisting the strategic management of intellectual and industrial property and the implementation of open models of innovation.

4.4. SUPPORT FOR RDI AIMED AT SOCIETAL CHALLENGES

Scientific and technical research and innovation are constantly evolving. The dynamics of this evolution respond to the nature of scientific knowledge and the technological advances recorded at earlier stages, which frequently generate novel proposals requiring radical changes in the evolution of science and technology, and which also obey the dynamics of the social changes that entail addressing new issues and seeking new solutions, that determine their dissemination. In this respect, the knowledge generation process and its applications cannot be understood without considering the issues and problems of our society. The SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION, while it remains in force, defends the orientation of scientific and technical research, technological development and innovation towards the major challenges facing Spanish society. These include health, old age, the application and defence of the principles for the inclusion of the most fragile segments of society, environmental sustainability, energy supply, biodiversity, the transformation of our political and social systems and the security of our citizens, and are in essence society's major global challenges.

Addressing the universal challenges facing our societies and making progress in the search for solutions capable of meeting both present and future demands resulting from the major process of change and transformation which we are experiencing, is one of the principles of action in the design of political RDI policies. This is reflected in the objectives of «Horizon 2020».

The promotion of RDI directed at societal challenges arises from the need to address the issues we face, and the objective of the SPANISH STRATEGY is to promote the scientific, technological and business leadership of

Spain in all those segments with high potential for growth at global level. For these reasons, the objective of the SPANISH STRATEGY is to guide the RDI activities, including fundamental scientific and technical research, technological development and innovation towards the EIGHT GREAT CHALLENGES listed below, which represent major markets for the development of new products and services:

1. Health, demographic change and well-being
2. Food safety and quality; productive and sustainable activity; sustainability of natural resources, marine and maritime research
3. Safe, sustainable and clean energy
4. Smart, sustainable and integrated transport
5. Action on climate change and efficiency in the use of resources and raw materials
6. Social innovation and changes
7. Economy and the digital society
8. Security, protection and defence

Because of their nature, these CHALLENGES encompass large fundamental areas which determine unique spaces for the multidisciplinary and inter-sectoral collaboration of the different stakeholders of the Spanish Science, Technology and Innovation System. What defines the measures to be implemented is not the sector or the discipline into which the stakeholders responsible for the implementation classify them, but the problem or challenge for which the RDI activities to be developed are intended to provide an answer, remembering that the final aim is to obtain social returns in the medium or long term, including those resulting from improvement in the competitiveness of the country's production network.

RDI directed at global societal challenges must necessarily combine the results of fundamental research, development and technological and non-technological innovation, which must be introduced for both the processes of dissemination and adoption of the proposed solutions and for the generation of products and services to help to meet these challenges. In addition, some of these measures must promote public-private collaboration; the latter will respond to flexible national and international collaborative structures, many of which require the mobilisation of private investment at the same time as the implementation of new public and pre-commercial procurement programmes with scalable solutions depending on the developments obtained.

The CHALLENGES to be tackled with RDI activities must be understood as the «problems of society to be resolved». The search for solutions to meet the global CHALLENGES requires a major effort in terms of basic scientific research, development and innovation developed by research groups both in the public and business sector and in collaboration. To address these challenges, it is essential for RDI actions to have the support of all the players involved, and, given that in some areas competences are transferred to the Regions, a very concerted and coordinated action with the Regions is also required. Similarly, promoting the participation of research groups, institutions and Spanish business in European projects, particularly in the framework of «Horizon 2020», is an issue of particular importance in the area of SOCIETAL CHALLENGES.

Research in Social Sciences and Humanities is envisaged as being transversal in nature and forms an essential part of scientific and technical research and of the innovations to be developed in search of solutions to societal challenges. We must be aware that many of the proposals will have a disruptive nature with significant effects on our consumer model, social harmony, behaviour, leadership and social and political relations. When defining the challenges and seeking innovative solutions, the importance of social behaviour and perceptions of science and technology, of the advantages and associated risks, must be taken into account insofar as these behaviours will encourage or prevent the innovation process itself.

A major component of technological perspective needs to be included in those RDI activities that aim to tackle global societal challenges. Consequently, the role of Technology Platforms, Alliances and other stakeholder of

the System will be promoted as channels of communication between the different public and private stakeholders, so that they play an essential role in the identification of emerging technologies, converging technologies, public-private collaboration and the detection of new demands on a global scale.

4.4.1. HEALTH, DEMOGRAPHIC CHANGE AND WELL-BEING

The demographic changes registered in recent decades, the constant increase in life expectancy and the legitimate desire to have a better quality of life and improved levels of health are factors which condition, among others, the future development and well-being of society. Knowledge generated in this area has been the basis for an authentic transformation in our perception of disease and its biological bases, affecting the framework in which effective preventive and therapeutic measures are developed in order to fight against disease, at a personal and collective level.

Research in health and in the national health system as a framework of fundamental development represents an essential value for Spain in the 21st century. RDI policies in Spain respond to the ultimate objective of improving public health, including research into the most prevalent diseases, clinical investigation into human diseases, public health and the health services, research into the biological foundations of pathologies and support for biotechnological applications in diagnostic and therapeutic developments and, lastly, the extension of personalised medicine, which is set out in the challenge as treatment of the person and not the disease. This is not to forget the need to introduce new practices and innovations in the provision of health services to maximise the use of resources, define a financial sustainability strategy and promote those activities aimed at the prevention and early detection of pathological processes that, over the long-term, permit an extension of the health culture and, consequently, a reduction in the burden to society of diseases. Therefore, the capacities of the National Health System in Spain represent a major competitive advantage for the development of inter-operability models and protocols, and the transmission of information. An international benchmark in this respect, Spain would act as a centre of innovation in health, leading to a major advance in terms of Information and Communication Technologies, concentrating, moreover, on the priorities established by the regulating stakeholders in a continuous monitoring process that responds to the principles of efficiency and effectiveness.

4.4.2. FOOD SAFETY AND QUALITY; PRODUCTIVE AND SUSTAINABLE ACTIVITY; SUSTAINABILITY OF NATURAL RESOURCES, MARINE AND MARITIME RESEARCH

At present, concern for food safety and the environment is a priority for developed societies. These must accelerate a technological transition to promote a sustainable economy and allow the following environmental, economic and social challenges to be address: (a) the production and sustainable management of agriculture, livestock farming, aquaculture, forestry resources and fishing, the agri-food chain and its traceability, the protection of agricultural and forestry crops, animal health and welfare, the production and transformation of biomasses and the mitigation and adaptation to climate change; (b) the increasing demand for healthier, safer and better quality food and bioproducts for non-food and energy use; (c) nutrition and nutritional genomics; (d) technological development, including biotechnologies applicable to the agri-food, fishing and forestry sectors, which are associated with the reduction, use and valuation of waste and subproducts; and (e) the development of new tools and smart management, alert and surveillance systems, to anticipate and adapt to the rapid evolution of RDI and market trends.

The areas linked to fishing, aquaculture and marine biotechnology and research are also of major importance for the RDI of our country, as are those related to the use and sustainability of soil and forestry resources, and continental water resources in irrigation, rural, urban and industrial environments, the use and sustainability of seas and oceans, along with the protection of the marine environment, adaptation to climate change and the prediction of natural hazards, including marine geological ones, floods and those of an anthropogenic origin.

The promotion of innovation in the SMEs of the agri-food sector, and the adoption of a model of sustainable and efficient production of resources using innovative management, production and manufacturing systems will be a key factor for the future business development of the Spanish economy as a whole, as it already has an auxiliary industry specialising in the agri-food sector and related sectors with high potential for technological and innovative development.

4.4.3. SAFE, SUSTAINABLE, CLEAN ENERGY

The specific objective is to sponsor the transition towards a safe, sustainable and competitive system, one that would reduce dependence on fossil fuels in a scenario in which their scarcity, the growth in world demand and their impact on climate change coincide. This requires close coordination between energy policies, policies to promote R&D and industrial policies, in addition to the joint action of Administrations and business stakeholders aimed at eliminating existing technological and legislative barriers and at establishing a suitable framework for the distribution of the costs and risks associated with the development of the new energy system. Given international commitments with respect to energy, it is necessary to coordinate the RDI measures resulting from this strategic framework with European funds earmarked for the energy sector, and in particular with the *Strategic Energy Technology Plan* (SET Plan) and the corresponding initiatives in which Spain takes part.

Together with the promotion and consolidation of renewable energies with respect to the capacities and competitive advantages existing in Spain, in line with the European Industrial Initiatives to Wind Energy, Solar Energy, Bioenergy, Marine Energy and Smart Networks, support will be given to the study of infrastructures for the capture and geological storage of CO_2 as a transition technology to mitigate the adverse effects of climate change.

Energy and environmental sustainability is conceived as an element of competitiveness and quality that must be considered at all stages in the construction process, and as an element of innovation for efficiency and the better use of resources. Therefore, measures will consider the move towards the international leadership of existing scientific, technological and business capacities in techniques for building construction and use, the introduction and application of new materials, construction processes, and systems aimed at improving the energy efficiency of residential and non-residential buildings.

4.4.4. SMART, SUSTAINABLE, INTEGRATED TRANSPORT

The promotion of operational and technological innovation in the transport sector, including good governance and its regulatory framework, is a priority for achieving the international leadership of the Spanish economy, and therefore it is essential to reinforce inter-administrative coordination, collaboration with the business sector and cooperation with third countries.

The strategic objectives in infrastructures and transport services in Spain aim to: (a) develop a system to permit the efficient, competitive, safe and affordable use of resources; (b) strengthen territorial cohesion and accessibility, favouring functional integration through an intermodal approach that establishes a new model in the relations among stakeholders; (c) guarantee the requirements for the access, quality and non-discrimination of all citizens; (d) conserve the environment and progress in the gradual replacement of non-renewable resources and in the integration of transport infrastructures in urban areas and in the surrounding landscape; (e) create efficient transport chains for people and goods through the inclusion and development of enabling technologies which encourage the implementation of innovative solutions; (f) boost the development of the next generation of means of transport and handling devices, especially through the use of automation and clean technologies, satellite navigation, etc., and (g) promote the international leadership of stakeholders with existing scientific, technological and business capacities in the analysis of the physical environment and in construction techniques and the operation of infrastructures and superstructures for transport, high-speed and high-

performance railway lines, in general, ports, airports and roads.

In short, to promote a change of model in the transport system based on sustainable mobility, the application of new less-contaminating solutions which are safer, better integrated and able to respond to the demands and usage of society.

4.4.5. ACTION ON CLIMATE CHANGE AND EFFICIENCY IN THE USE OF RESOURCES AND RAW MATERIALS

Climate change is one of the greatest threats to our society and has implications in all aspects of sustainable development. It is a key element of European and international policy and requires research, development and innovation in scientific knowledge to be strengthened, and the fight against the causes and its impact in Spain to be carried forward, due to the country's significant vulnerability in this regard. Therefore it is essential to improve the scientific knowledge of the processes and operating mechanisms of the oceans, land ecosystems and the atmosphere, and the options to adapt to and mitigate climate change.

Consequently, the area related to water resources deserves special mention, in particular, integrated water management systems and technologies aimed at efficiency of use in irrigation, rural, urban and industrial environments and all activities that make it possible to advance in the protection of aquatic ecosystems, seas and oceans. Given the special significance and impact countrywide, we must promote activities designed to prevent and reduce the devastating effects of forest fires, biodiversity, resources, and the natural, rural and urban environment.

Desertification, forest fires, erosion and impoverishment of the soils, the reduction in freshwater resources and the progressive salination of water reserves, together with the contamination, overexploitation and loss of biodiversity, are unmistakeable signs that there is an urgent need for measures designed to help to ensure a more efficient use of natural resources and to guarantee environmental integrity as a factor of competitiveness and the social and economic development of the country. We need to activate the transition towards a new production model that reduces the pressure on the environment, natural resources and raw materials and which leads to the application of less contaminating industrial processes, in addition to promoting the existing major technological development linked to the need for advanced instrumentation to address the relevant challenges linked to climate change.

4.4.6. SOCIAL INNOVATION AND CHANGES

Social processes are a crucial factor in the innovation process; they are an active agent of the latter and a vehicle of the values, models of behaviour, transformation and adaptation that technological change and innovation entail; as such they form a transversal field of research to all SOCIETAL CHALLENGES. Research into Social Sciences and Humanities must contribute to the design of solutions that lead to an innovative, inclusive and responsible society in an unprecedented context of change and transformation.

In recent years we have witnessed far-reaching social transformations that pose major challenges for Spanish society, including the expansion of education, the new configuration of the occupational structure, the progressive inclusion of women in the world of paid employment and the social, economic and cultural impact of migratory flows. The provision of efficient and effective public services, the Administration's relation with businesses and citizens and the new paradigms of citizen participation, transparency and open government are significant challenges for the Administration and for society.

The above changes and trends, which may be listed as structural, bring new realities, questions and queries to which scientific research in Social Sciences and Humanities must provide an answer in order to improve our

understanding of the present situation, the quality of public policies and the strategies of the economic and social stakeholders.

In addition, history, local cultures and resources and heritage have an essential value in the construction of identities and common values; therefore research in Humanities is a key element in the construction of citizen values, in the learning of our own history and in the identification of solutions for SOCIETAL CHALLENGES. Hence it is essential to promote research, development and innovation applied to the conservation and sustainability of the important artistic, archaeological, historic, cultural and social heritage of our country and its contribution to the social and economic development of the regions.

4.4.7. ECONOMY AND THE DIGITAL SOCIETY

The introduction of digital technologies and the development of the Information Society is transforming the economy and society towards a digital environment that is progressively advancing and has become transversally implemented in all sectors of economic activity; it is becoming the dominant scenario for economic transactions, the provision of services, the definition of a new model for organising work and social relations. In the next few years, no sector will be able to remain on the periphery of a transformation which will change the way business is conducted, the available products and services, sales channels and the mechanisms for consumer relations. The leveraging of industrial and commercial opportunities and the provision of services relating to this process of evolution are one of the main development opportunities for the country's economy. The change towards this digital society model cannot be understood unless the majority of citizens regularly browse the net and take advantage of the new opportunities. Digital inclusion, including the development of the principles of universal accessibility for the disabled, the generation of new capacities and the adaptation of training models requires a firm commitment to innovation in these areas.

To meet the above challenges, technological and social research and innovation will play a vital role in making new breakthroughs to mobilise this transformation process towards the digital society and economy available to the public, businesses and administrations.

Commitment to ICT-linked RDI activities has been recognised by the European Union in its Digital Agenda for Europe. The latter has established the doubling of the total annual public expenditure on the research and development of ICTs as an objective for member countries, in order to produce an equivalent increase in private expenditure.

4.4.8. SECURITY, PROTECTION AND DEFENCE

The globalisation process that has emerged over the last thirty years has led to a growing interdependence which increases the vulnerability of society, citizens and institutions. The latter represent principles and values which have underpinned the development of the principles of social harmony and the governance of European societies. The objective is to promote safe societies in a changing, interdependent environment increasingly subject to global threats, by enhancing the culture of freedom, responsibility and justice.

This challenge is of a global nature and is of crucial importance as a consequence of international events and the processes of social, political and strategic change that are taking place. The threats to our country in terms of safety and defence spill over any country's borders and require intense international cooperation. This cooperation, which has an indubitable geopolitical and strategic dimension, extends to critical questions such as maritime and air safety, terrorism, safety of the web (*cibersecurity*) and the need to have access to capacities in order to respond to situations of emergency of any nature, as reflected in the *Spanish Security Strategy*, which lists the principal guidelines to be followed in this area.

The objective is to contribute to the design of coordinated policies at international level in all the areas which strengthen national security and defence capacities, by promoting the development of technologies and innovations that help a competitive security and defence industry thrive at international level. Given the position of leadership that the security and defence industry has traditionally had in multiple technological areas, the knock-on effects and the transfer of the advances achieved to other productive sectors will have a positive effect on the welfare of society.

5. PRIORITY LINES OF ACTION

The SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION in turn includes a total of six priority lines of action that reflect the characteristics of the *Spanish Science, Technology and Innovation System* and which guide the actions of the public Administration in order to correct the weaknesses observed and to define a coordinated roadmap to guide all the structural and systematic reforms that must be tackled with urgency in order to make the System efficient, flexible and competitive.

These priority lines of action are:

- DEVELOPMENT OF AN RDI-FRIENDLY ENVIRONMENT
- AGGREGATION AND SPECIALISATION OF KNOWLEDGE AND TALENT
- TRANSFER AND MANAGEMENT OF KNOWLEDGE
- INTERNATIONALISATION OF THE SPANISH SCIENCE, TECHNOLOGY AND INNOVATION SYSTEM AND ITS STAKEHOLDERS
- REGIONAL SPECIALISATION AND DEVELOPMENT OF INNOVATIVE AND COMPETITIVE REGIONS
- INNOVATIVE AND ENTREPRENEURIAL SCIENCE CULTURE

5.1. DEVELOPMENT OF AN RDI-FRIENDLY ENVIRONMENT

In the environment in which the stakeholders of the System act, the following persist: (1) regulatory models and management practices that inhibit innovation and the adoption of suitable instruments for boosting RDI, especially in the public sector; (2) a complex structure in terms of legislation and administrative competences which imposes high transaction costs on all stakeholders; (3) a model for funding RDI that does not allow the needs of System stakeholders to be met, including the scarcity of initiatives to maintain innovative business projects along their chain of growth; and (4) major barriers to innovation associated with a science and technology culture based on entrepreneurship that continues to lack presence.

The promotion of the *Spanish Science, Technology and Innovation System* associated with the objectives of this STRATEGY requires an institutional, regulatory, financial, economic and social environment that stimulates and facilitates innovation and that transcends the direct incentives earmarked for the promotion of RDI. It is the role of the Public Administrations, within their competences, to secure an environment which is favourable to the consolidation and development of RDI with the establishment of suitable regulatory frameworks, by encouraging greater involvement of the private sector and increased participation in European RDI projects and access to the corresponding funds.

Therefore, to create an RDI-friendly environment it is necessary to address, as a priority and basic element, the adoption of a set of measures designed to: (a) improve the governance of the public institutions in the *Spanish Science, Technology and Innovation System*; (b) enhance public-private collaboration; (c) encourage and facilitate private investment in RDI; (d) improve the conditions of private funding of RDI activities including, where applicable, tax incentive measures; (e) support the creation of IT-based companies and promote an entrepreneurial culture in universities and public organisations to drive innovation and the setting up of *spin offs*; (f) provide the System with a good management model for industrial and intellectual property rights; (g) include

technological surveillance and competitive intelligence as part of the innovation process, and (h) encourage a new model of public RDI policies based on demand that stimulates the generation of business leadership capacities in RDI.

Companies require an appropriate financial structure in order to address challenges, including innovation and/ or investment in RDI as their basis for competitiveness. In other words, the entrepreneur needs to have sufficient resources of their own, according to the dimension of the challenges, together with access to outside resources to help them to complement the funding required to embark on their investment projects. Therefore, employing risk capital throughout the chain of growth of innovative companies is a question still to be addressed in the *Spanish Science, Technology and Innovation System,* to which this STRATEGY pays special attention through the numerous instruments and initiatives that guarantee funding using efficient Venture Capital instruments that cover the different phases of business development, from seed and start-up funds to subsequent rounds that sustain scaled support without discontinuity at all stages of the business projects.

With respect to private funding for RDI, there is a significant margin of development for increasing the participation of all the social stakeholders in the financing and support of Science, Technology and Innovation through interventions designed to encourage patronage, micro-patronage, collective savings for R&D and sponsorship, in addition to optimising tax incentives for RDI. Thus companies that champion technological innovation as an element of competitiveness and sustainability will contribute to the promotion of Corporate Social Responsibility (CSR) as an active and voluntary contribution to the social, economic and environmental progress of our environment.

The promotion of innovation through demand policies associated with public procurement, which in Spain accounts for more than 16% of GDP, is an instrument that must be developed with the establishment of a suitable legislative framework, of which the revision of the general framework for public sector contracting forms part. Moreover, the introduction of conditions that permit the positive valuation of innovation in accordance with the general framework for public sector contracting must be carried out in accordance with the new directives on public contracting for which the obligatory transposition period is established for 2014. Likewise, progress is required in the development of new innovative public contracting measures associated with RDI activities aimed at Societal Challenges in order to strengthen the leadership role in terms of Public Administration Innovation. In addition, through the certification that accredits «innovative SMEs», including as a specific case the «the Young Innovative Company stamp», access to specific lines that may be developed will be facilitated, where applicable.

5.2. AGGREGATION AND SPECIALISATION OF KNOWLEDGE AND TALENT

The generation of knowledge and talent are fundamental pillars for increasing social welfare and competitiveness of a region. Therefore, they are considered as transversal elements in all actions undertaken and a strategic priority in the public actions with respect to RDI. Scientific and technical research increasingly requires the existence of research groups in more and more specialised fields or areas with a critical mass in order to enable them to advance in the generation of new knowledge and at the same time collaborate with other stakeholders in the System, whether public or private, to increase their own RDI capacities as a result of this aggregation. In addition, the aggregation of capacities, together with the scientific and technical specialisation of the implementing stakeholders, allows the strengths and potential for excellence of each of the stakeholders in the System to be identified and leveraged and the critical mass required for international leadership to be attained.

The objective is to promote the generation and management of knowledge by optimising the resources of the different stakeholders in the System and to promote its impact through specialised collaboration networks of scientific, technical and innovation research groups who either share a common space, through research

institutes, scientific and/or technological parks, specialised research clusters or any other organisational form of collaboration, etc.) or are distributed throughout the national or international region (e.g. networking research centre, strategic alliances, European research networks, etc.).

In order to do so, it is necessary to create a coordinated and coherent process to promote the generation of knowledge in line with the necessary scientific and technological specialisation and aggregation of capacities from a critical mass that the research group is unable to achieve independently. In addition, the creation of interdisciplinary and intersectoral networks permits knowledge and technologies to be shared, thereby promoting an additional value in the science, technology and business system that other types of strategies cannot reach.

Therefore, a strategy based on specialised aggregation offers, on the one hand, a more competitive critical mass but, on the other hand, it promotes an improved use of the infrastructures and equipment, increased mobility of researchers and technologists and, therefore, a more efficient system.

Similarly, specialised aggregations of research and innovation must meet social demands and regional production sectors, especially those of the more innovative and knowledge-based companies. The aggregation of production sectors in specialised networks favours the transfer of knowledge, intersectoral mobility, the identification and development of new competitive products and services and the improvement of social and economic development, by transforming the region into ecosystems of knowledge, technology and innovation.

5.3. Transfer and Management of Knowledge

The process whereby scientific and technical knowledge is made to impact on social welfare is complex; it does not respond to easily predictable linear models and requires the intervention of stakeholders with clearly differentiated skills and capacities. In addition, opportunities for innovation are increasingly greater outside the traditional limits of organisations, sectors and disciplinary areas. In this respect, «*open innovation*» involves multiple internal and external stakeholders, includes new tools for the management of property rights and the enhancement of knowledge and considers all the intangible dimensions of the process.

Thus, the measures to be adopted must involve all the stakeholders in the System and be aimed at: (a) detecting innovative research and technological groups with a high potential for application in sectors and technologies key to our economy; (b) developing systems of economic and competitive intelligence and surveillance tools for the capture, analysis and dissemination of results; (c) defining models for protecting knowledge and the results of research that facilitate transfer and use of the latter; (d) establishing efficient mechanisms for the transfer of technology and commercialisation; (e) promoting relations between R&D centres, researchers and businesses and stimulating the mobility of researchers, technologists and technicians and stable public-private collaboration, and (f) the inclusion in the System, both in the public and private sectors, of RDI management professionals.

In this context, a significant number of the measures derived from the objectives of the Spanish Strategy on Science, Technology and Innovation are directed at encouraging dialogue and communication between the stakeholders of the System, in order to generate a degree of confidence among them through the creation of instruments that improve quality and legal security. This guarantees the strategic management of industrial and intellectual property rights, transfer of knowledge, and commercialisation of research results and establishes the bases for the implementation of open models of innovation. At this point it is important to highlight the creation of new technology-based companies as a channel for the commercialisation of the results of RDI, and the strengthening of the entrepreneurial activity originating in the university and in other R&D centres. The commercialisation of research results through the creation of companies represents a huge challenge that

requires the commitment of many varied resources including the training in entrepreneurial management of professionals in R&D centres.

Measures in favour of the transfer and management of knowledge shall include, among others, three fundamental dimensions: (1) intersectoral transfer to accelerate processes for the application and adaptation of knowledge, technologies and patents in different sectors; (2) interregional transfer directed at generating synergies between the RDI systems of the different regions, and (3) transfer between the stakeholders of the *System* resulting from close collaboration and participation prior to the attainment of results, and which connects and anticipates future needs through an efficient network of structures, such as Technology Platforms, Alliances for Science and Innovation, Technology Centres, Science and Technology Parks, University Foundations and other public organisations, transfer units and others which act as an interface between researchers and the production network.

5.4. INTERNATIONALISATION AND INTERNATIONAL LEADERSHIP

The globalisation of knowledge, of technologies and of innovation markets makes the international leadership capacity of public institutions, universities, businesses and research groups a decisive and differentiating factor in a highly competitive environment. The setting in which scientific and technical knowledge is developed and in which innovations take place is extremely dynamic; this characteristic has meant that countries that have traditionally enjoyed an unassailable position of scientific and technological leadership now face the challenge associated with the growing importance with respect to RDI of third countries, even more so among the BRIC countries BRIC -Brazil, Russia, India and China.

In Spain, the relatively recent construction of the *Spanish Science, Technology and Innovation System* explains the limited extent to which it has opened out internationally speaking, in spite of which significant advances have been registered in indicators including: (a) international scientific collaborations; (b) participation in international programmes, organisations and infrastructures such as the European R&D Framework Programme, the CERN, the European Space Agency, the ITER project and the EMBL, among others, and (c) increased business participation in bilateral and multilateral programmes for technological cooperation.

Meanwhile, the evolution of European Union RDI projects requires increased coordination between national and European policy with respect to RDI, and the encouragement of researchers, research centres and businesses to participate in the development and consolidation of financing instruments designed for this purpose, including in particular the new European RDI framework programme, "Horizon 2020", which for the first time covers the complete cycle, from when the idea is born until it goes to market.

In short, the international projection of both public and business System stakeholders is an essential critical competitiveness factor that affects the development of the *Spanish Science, Technology and Innovation System* itself and must contribute to increasing scientific, industrial and business capacities in Spain with the purpose of:

a) Optimising the SYNERGIES BETWEEN THE ACTIONS TAKEN IN SPAIN WITH RESPECT TO RDI AND THOSE ESTABLISHED BY THE EUROPEAN UNION AND ITS MEMBER STATES creating an INTEGRATED FRAMEWORK OF COOPERATION which guarantees the maximum impact of the actions which have been designed and funded, considering the scientific and technical capacities of the groups and countries involved.
b) Strengthening the links for SCIENTIFIC, TECHNICAL AND BUSINESS COOPERATION WITH THIRD COUNTRIES, especially with Latin America and the Mediterranean Countries in which there is a long history of collaboration and significant complementarities.
c) Supporting the actions carried out within the framework of the national foreign policy, and thus enhancing SPAIN'S RELATIONS AND COLLABORATIONS WITH THIRD COUNTRIES in the areas of science,

technology and innovation and with International Organisations, and supporting the international cooperation policy for development.

d) Increasing SPAIN'S ATTRACTIVENESS and that of the stakeholders for the Spanish System as a source of SCIENTIFIC AND TECHNICAL RESEARCH OF EXCELLENCE, both because they are environments with capacities FOR ATTRACTING TALENT AT GLOBAL LEVEL, and large international scientific and technological infrastructures and investments in RDI in close collaboration with Autonomous Regions
e) Promoting the INTERNATIONAL PRESENCE OF INNOVATIVE SPANISH COMPANIES and enhancing their presence and participation in commercial networks and global markets.
f) Promoting the «SPAIN BRAND» abroad and its relation with scientific research of excellence and with business leadership in key sectors of our economy.
g) Improving the VISIBILITY OF SPANISH SCIENCE ABROAD, mainly through the creation and consolidation of communities of Spanish researchers abroad.

In addition, the SPANISH STRATEGY provides for the development of a set of ***measures for encouraging Spanish participation in European RDI programmes***. These would be structured in accordance with the objectives established in the former and included in the corresponding plans and actions, both of central and regional governments. Consequently, the measures include: (1) the promotion of talent through the inclusion of RDI technologists and managers specialising in European projects. (2) The promotion of scientific and technical research of excellence through the detection of new research groups with the potential to participate in European programmes; support for the presentation of proposals from public centres; funding of projects approved and not financed by the European Research Council (ERC) and the creation and deployment of the support network for participation in «Horizon 2020». (3) The empowerment of business leadership by identifying new businesses with capacity to participate in «Horizon 2020»; support for the presentation of competitive business proposals, and the reinforcement of Technology Platforms and other players with leadership possibilities at European level.

In this context, special attention should be paid to support for the participation of groups, institutions and businesses in RDI projects aimed at resolving SOCIETAL CHALLENGES. The aforementioned determine the aspects on which international RDI cooperation measures will be focussed. For this purpose, the joint programming instruments available for the start-up of ambitious R&D projects will be used, providing infrastructures or completing the financing percentages, and the transfer of results and demonstration, thanks to top-ups and research funding.

Lastly, support will be given for other measures to increase the coordination and search for synergies between national and European actions which take complementarity between regional European funds and those allocated to RDI into account, and the increase in the criteria linked to the internationalisation of stakeholders and participation in international activities, mainly in the European Union, as part of the evaluation criteria of Spanish calls for tenders.

5.5. INNOVATIVE AND COMPETITIVE REGIONS: «SMART REGIONAL SPECIALISATION»

Territorial reality, both regional and local, is a crucial element that determines the promotion of economic and social development, encourages or inhibits the competitiveness of small- and medium-sized enterprises and impacts on the response capacity to the challenges of globalisation. The regions must adopt a new approach in order to permit their business network, particularly that of SMEs, to develop a high growth potential by opening up towards global markets and specialised demands, many of them in emerging market niches with a high innovation component so as to achieve their integration in the global production networks and chains.

The Regional Science, Technology and Innovation Systems are of vital importance for the *Spanish Science, Technology and Innovation System* to operate and to develop successfully; consequently, the SPANISH STRATEGY supports the complementarity of the scientific, technical and innovation capacities and the production

capacities existing in the Regions, so that the system will acquire an overall vision on a national level, by providing a better connection with «Horizon 2020» and the rest of the European Union policies aimed at promoting RDI activities. At this point, an appeal is made to seek synergies among the different measures for promoting the RDI existing in the European Union, which must maximise the impact of public measures aimed at RDI in terms of territorial development and cohesion and economic growth.

In line with the new governance model of the *Spanish Science, Technology and Innovation System* and for the purpose of achieving greater social, economic and regional coordination, the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION is the framework for coordination and collaboration that must stimulate and promote the capacities of each of the Regions, leveraging their strengths and addressing their weak points, thus helping each one to maximise their opportunities. Under these premises, the SPANISH STRATEGY supports alignment with the instruments and strategic objectives defined in the framework of the new «smart specialisation strategies» -RIS3-, which represent the *ex-ante* condition required by the European Commission for the awarding of the corresponding funds to cohesion policies, thereby generating a competitive and sustainable model of economic, social and territorial development based on innovation.

Consequently, the integration of the *Smart Specialisation Strategies* in the framework of the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION leads to the preparation of an integrated agenda with the Autonomous Regions to promote the productive and regional transformation based on: (1) support for RDI activities directed at the demands of the System's stakeholders; (2) the intensive use of information and communication technologies, and (3) the boost to business development and the competitiveness of small- and medium-sized businesses.

Closely linked to the CHALLENGES OF SOCIETY AND THE DIGITAL ECONOMY are the development and promotion measures relating to the so-called «smart cities», urban environments that are moving towards the economic and social transformation of their territories through coordinated initiatives and investment linked to: (a) human and relational capital; (b) the creation of new infrastructure and communication networks; (c) the promotion of knowledge and innovation; (d) the adoption of smart and sustainable transport models; (e) environmental and resource sustainability, and (f) the introduction of a new management and governance model based on extensive citizen participation.

5.6. SCIENTIFIC, INNOVATION AND ENTREPRENEURIAL CULTURE

The achievement of the objectives established in the framework of the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION require transversally that the actions to be implemented provide for the need to enhance scientific and technological culture and creativity in Spanish society and, in particular, among the younger generations. The challenge is to familiarise citizens with science, technology and innovation, thereby narrowing the gap between the world of science and technology and society in general. Consequently, with respect to the dissemination of the results of RDI activities, the image of research, technology and innovation will be defended as activities that promote the development and well-being of society.

A society's scientific culture cannot be separated from education, training and the dissemination of information, in addition to acknowledgement of the activities carried out by the stakeholders of the *Spanish Science, Technology and Innovation System*. Therefore, support will be given to the development and consolidation of networks for the communication and dissemination of science. Likewise, innovation culture must be included as an essential element in order for new science and technology vocations to emerge; consequently, in the area of education, priority will be given, from the first stages, to activities that promote a critical spirit, understanding of the scientific method and interest in science, endeavour and innovation.

Spanish society's culture of science, technology and innovation must be reflected in the creation of a favourable environment in which creativity and endeavour are included as fundamental values of the younger generations, acting as a lever for social, cultural and economic change.

6. COORDINATION MECHANISMS

The *Spanish Science, Technology and Innovation System* is complex management-wise and heterogeneous in its results; to date it has not had a shared vision and common objectives enabling its stakeholders to compete in a globalised and dynamic environment and securing access to the *European Research Area*. The characterisation of the *Spanish Science, Technology and Innovation System* as a *«system of systems»* must address a functional reality. As such, it must have a stable framework of political and administrative collaboration and shared responsibility to enable political, regional and sectoral coordination, aimed at increasing the efficiency and impact of public intervention with respect to RDI, thereby avoiding overlapping.

The *Law on Science, Technology and Innovation* allows a new model of governance to be attained for the functional articulation of the Spanish System, thanks to the setting up of the Science, Technology and Innovation Policy Council. This is reflected in the very process of production and in the contents of the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION, in which greater integration has been sought between the policies to promote RDI and sectoral policies and their relation to the production capacities of the country.

However, to attain the objectives of the STRATEGY, progress must be made in the coordination mechanisms that must achieve the coordinated action of the Public Administrations.

The development of this STRATEGY envisages the coherent use of **six** coordination mechanisms:

1. The co-responsibility of all the Public Administrations in the attainment of the objectives and commitment to the established priority lines, including the implementation of JOINT PROGRAMMING AND CO-FINANCING INSTRUMENTS, to oversee the development and consolidation of the capacities of the *System* and the scientific, technological and business leadership of their stakeholders, together with the co-financing of Singular Scientific and Technical Infrastructures, based on scenarios in line with their level of scientific and technological evolution and the established borrowing capacities.
2. OPEN ACCESS to data and microdata, and to the publications and results of research financed with public funds, including the preparation of guidelines to provide individual or shared repositories.
3. The development of an INTEGRATED INFORMATION SYSTEM and the improvement of the quality of the indicators for monitoring the actions financed by the Public Administrations and their impact.
4. ADMINISTRATIVE STREAMLINING and simplification of public measures and the adoption of procedures and instruments based on simple, flexible and dynamic schemes to gradually reduce the transaction costs borne by stakeholders, thereby improving communication and interaction with the latter.
5. The HARMONISATION OF EVALUATION CRITERIA AND PRACTICES, *ex ante* and *ex post*, enshrined in the best international practices which seek agent competence in the allocation of public resources and the promotion of funding by results, including firm support for assessment practices involving independent international experts.
6. The adoption of measures, reforms and the design of instruments to raise the levels of BUSINESS INVOLVEMENT and increase the percentage of business participation in the funding of RDI, together with the attraction of investment in R&D from abroad and by foreign companies.

In conclusion, attainment of the objectives established requires a stable framework in the actions of the different Administrations involved, in addition to the establishment of communication and information channels and procedures to guarantee adequate representation of the interests of all the regions, institutions and their stakeholders.

7. EFFORT, RESULTS AND IMPACT INDICATORS

A coherent evaluation of the initiatives and activities implemented deriving from the objectives and priority lines of action established in the STRATEGY is a fundamental exercise with a view to certifying the monitoring of public action in the fields of science, technology and innovation. Therefore, the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION includes a set of indicators that allows measurement of the degree of commitment of the stakeholders responsible for the definition of public RDI policies to the established objectives and priorities. The indicators also results to be monitored.

In this framework, a set of indicators and goals is proposed whose purpose is to measure the effort and results which:

- are the result of an ambitious commitment and that in turn realistically respond to the scientific, technological and innovation capacities of the System which must be valued.
- facilitate international comparison, in particular with the indicators selected for the objectives shared with «Horizon 2020».
- are indicators that correspond to the proposed objectives and the measures designed to achieve these and address the aggregation of the efforts of all the stakeholders involved.
- must reflect the medium- and long-term impact on the improvement of the competitive position of the Spanish economy and its capacity for generating activity and employment with a high added value.

The achievement of the objectives established in the SPANISH STRATEGY ON SCIENCE AND TECHNOLOGY AND ON INNOVATION requires a significant provision of resources allocated to financing RDI countrywide, of both a public and private nature. Together with the efforts to be made throughout its effective term by the Public Administrations and which, in the short-term, are subject to the necessary fiscal consolidation measures, the SPANISH STRATEGY envisages the indicators for measuring effort as being the following:

- Increase the degree of involvement and participation of the private sector in investment in RDI in Spain, for which purpose the Administrations undertake to define the conditions and provide access to efficient instruments to guarantee greater leveraging of private investment.
- Substantially increase the procurement of resources from abroad, mainly through the participation of the programmes established by the European Union and the attraction of investment in RDI by multinationals and foreign businesses or by attracting investment funds and/or venture capital.
- The commitment of Public Administrations to keeping the investment made in funding RDI stable and sustained over time.

In this respect, the goal established for the whole of the European Union of achieving expenditure of 3% of GDP on RDI by 2020 involves the mobilisation of significant private investment in RDI that must be qualified according to the characteristics of each of the Member States. Therefore, in Spain, realistically, the proposed objective is to reach a level of investment in RDI of 2 % by 2020. Table 2 below includes the principal indicators associated with the SPANISH STRATEGY together with the values to be reached by 2020. These are indicators from the *Spanish Science, Technology and Innovation System* associated with the objectives indicated above and the measures that, in terms of RDI policies, must be promoted in order to achieve this. It also considers the review of the Spanish Strategy on Science and Technology and on Innovation and the evaluation of the activities embarked upon in 2016, and therefore includes the values in the evolution of the indicators selected for this date.

Table 2 Indicators for the SPANISH STRATEGY ON SCIENCE, TECHNOLOGY AND INNOVATION

EFFORT INDICATORS	2010	2016	2020
EXPENDITURE ON R&D AS PERCENTAGE OF GROSS DOMESTIC PRODUCT (%) SOURCE: INE	1.39%	1.48%	2.00 %
PRIVATE SECTOR EXPENDITURE ON R&D AS PERCENTAGE OF GROSS DOMESTIC PRODUCT (%) SOURCE: INE	0.60%	0.73%	1.20 %
RATIO BETWEEN PRIVATE AND PUBLIC FUNDING OF EXPENDITURE ON R&D SOURCE: INE	0.86	1.06	1.70
% OF FUNDING OF EXPENDITURE ON R&D FROM ABROAD SOURCE: INE	5.7%	9.6%	15.0 %

RESULT INDICATORS	2010	2016	2020
PHD GRADUATES (%) IN THE REFERENCE AGE-GROUP OF 25-34 SOURCE: OECD	0.9‰	1.2‰	1.6‰
INTERNATIONAL STUDENTS ENROLLED ON ADVANCED HIGHER EDUCATION PROGRAMMES/TOTAL NUMBER OF STUDENTS ENROLLED (%) SOURCE: OECD	10.8%	14%	20%
PERSONNEL EMPLOYED IN R&D /TOTAL EMPLOYED POPULATION (‰) SOURCE: OECD	11.8‰	13.0‰	16‰
POPULATION EMPLOYED IN R&D WITH PHD STUDIES AS % OF TOTAL EMPLOYED POPULATION SOURCE: EUROSTAT	21.4%	23.0%	25.0%
INCREASE IN % OF PUBLICATIONS IN JOURNALS WITHIN 10% OF THE TOTAL SCIENTIFIC PUBLICATIONS FOR THE PERIOD SOURCE: THOMSOM REUTERS, JCR	-	25%	50%
% OF PUBLICATIONS GENERATED BY PROJECTS FUNDED WITH PUBLIC RESOURCES THAT ARE AMONG THE MOST QUOTED 5% IN ITS FIELD AT GLOBAL LEVEL[*] SOURCE: ELSEVIER, THOMPSON REUTERS	-	3%	10%
INCREASE IN THE NO OF PROJECTS FUNDED BY THE EUROPEAN RESEARCH COUNCIL (STG)[***] SOURCE: ERC	-	60%	90%
INCREASE IN THE NO OF PATENTS APPLIED FOR IN EMERGING TECHNOLOGIES [*] SOURCE: WORLD INTELLECTUAL PROPERTY ORGANIZATION	-	25%	50%
BUSINESSES MAKING TECHNOLOGICAL INNOVATIONS AS % OF TOTAL ACTIVE BUSINESSES WITH 10 OR MORE WAGE-EARNERS (%) SOURCE: INE	18.58%	20.0%	25.0%
% OF SME MAKING TECHNOLOGICAL INNOVATIONS, PRODUCTS AND PROCESSES, AS % OF TOTAL SME SOURCE: INE	14.6%	16.0%	20.0%
% OF HIGH AND MEDIUM TECHNOLOGY EXPORTS AS % OF TOTAL PRODUCT EXPORTS SOURCE: INE	4.7%	6.0%	10%
INCREASE IN THE NUMBER OF PATENTS APPLIED FOR IN DIFFERENT ENABLING AND ESSENTIAL TECHNOLOGIES [*] SOURCE: WORLD INTELLECTUAL PROPERTY ORGANIZATION	-	25%	50%
NO OF COMPANIES THAT HAVE MADE TECHNOLOGICAL INNOVATIONS, PRODUCTS AND PROCESSES, IN COLLABORATION WITH PUBLIC CENTRES AND UNIVERSITIES SOURCE: INE	23%	30%	45%
INCREASE IN NO OF PATENTS APPLIED FOR AND SECTORAL DISTRIBUTION LINKED TO THE SOCIETAL CHALLENGES [*] SOURCE: WORLD INTELLECTUAL PROPERTY ORGANIZATION	-	25%	50%
INCREASE IN % OF PUBLICATIONS GENERATED BY PROJECTS FUNDED WITH PUBLIC RESOURCES WITHIN THE SOCIETAL CHALLENGES THAT ARE AMONG THE MOST QUOTED 10% IN ITS FIELD AT GLOBAL LEVEL[*] SOURCE: ELSEVIER, THOMPSON REUTERS	-	25%	50%
RETURN OF PARTICIPATION OF RESEARCH GROUPS, BUSINESS AND OTHER STAKEHOLDERS IN H2020 AND OTHER EUROPEAN INITIATIVES[***] SOURCE: FECYT	8.6%	11%	15%
INCREASE IN THE VOLUME OF VENTURE CAPITAL FUNDS INVESTED (PUBLIC AND PRIVATE, NATIONAL AND FOREIGN) WITH RESPECT TO PREVIOUS YEAR[*]	-	5%	12%

SOURCE: EUROSTAT			
EVOLUTION OF SOCIAL VALUATION IN FAVOUR OF SCIENCE AND TECHNOLOGY [***] SOURCE: FECYT	56.4%	59%	70%

[*] INDICATORS OF RESULTS FROM HORIZON 2020
[**] INDICATORS OF PERFORMANCE FROM THE MULTIANNUAL FINANCIAL FRAMEWORK 2014-2020

APPENDIX. Index of Figures and Tables

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