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Research Policy: a Bottom-up Contribution to European Integration and to Successful Implementation of Other EU Policies

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Abstract: Research policy, aimed at increasing competitiveness of the European productive system, is implemented through strategic actions, the most relevant of which is increased public and private investments in strategic industrial research and innovation, but it includes also investments in education, lifelong learning, and technological infrastructures. We prove that research policy is playing a role over and above the institutional objective of competitiveness.

Research and development (R&D) programs lead to an upgrade in the scientific, cultural, and technological level of participants and contribute to the path towards political union, to the irradiation of European values within and beyond European boundaries, and to the implementation of other policies. EU research programs generate high return on the investment. It is estimated that current Community contribution of € 7 billion/year might generate a GDP increase of € 200 billion/year in the 2030s. Intangible results are also momentous. In this paper we address the impact of research on other policies: Competition, Consumer Protection, Employment, Energy, Enlargement, Enterprise, Environment, Information Society, Institutional Affairs, Internal Market, Mobility, Public Health, Regional Policy, and Transport.

R&D policy was put at the heart of the Lisbon Strategy (LS) to boost employment and growth in Europe. LS suffered of major weaknesses, described in the paper; it had however, a role in putting R&D center stage in EU strategic planning for sustainable growth and in creating the conditions for the member states to decide for a major increase of R&D public spending, thus reinforcing the most effective component of the LS, the Framework Program, built on strengths of proved effectiveness: the involvement of all stakeholders in its planning, the feeling of ownership by the scientific/industrial community, focused funding, strict monitoring of execution, and enhanced exploitation plans.

Community funding is the incentive to face the intrinsic complexity of international collaborations, an incentive ever so much important in EU27 to overcome the diversity in business culture, business practices, innovation, and workforce qualification across the enlarged Union. Diversity makes integration more complex and introduces additional costs to international cooperation, but it is an asset and a point in favor of the EU within the Triad. It facilitates addressing and understanding competitors in a world where new actors from remote markets and with different cultures take increasingly relevant roles. Changes triggered by research policy are bottom up and affect people in the first place: researchers, industrialists, students. By getting to know their peers in other countries, European participants in the programs learn to respect and appreciate diverse cultures, overcome the barriers that divided Europe, experience the feeling of belonging in a community larger than their own country, and establish networks that are the ground culture for European citizenship. Changes triggered by research policy affect enterprises as well. They broaden their horizon and they experience the advantages of international collaboration, known to universities for centuries. This bottom-up action complements and is supported by the institutional activities of the EU and builds a community *united in diversity* capable of facing the challenges of a globalized world.

Building a world of solidarity, welfare, and peace was the project and the vision of the EU founding fathers that inspired all the EU policies implemented in the past 50 years, including, of course, Research Policy —one of largest single expenditure item in the EU budget. In 2009, the biggest share of the EU budget (45% or €60 billion) will go to research, innovation, employment, and regional development programs, combining short and longer-term measures to help Europe respond to the current economic crisis as quickly and effectively as possible [EC 2009-1]. Of these €60 billion, over €7 billion are the 2009 EU funding of research programs under the 7th Framework program for Research and Technological Development. The aim of Research Policy is to increase the competitiveness of European enterprises and of their products, processes, and services. It is implemented through a series of strategic actions, the most relevant of which are the increase in public and private investments in industrial strategic research and in innovation, but it includes also investments in education, lifelong learning, and technological infrastructures.

The European Union is a region with high labor costs. The costs for salaries, social services, education, training, health, and environmental protection can be only partly compensated by increasing productivity of the labor force, improving efficiency of public administration and taking full advantage of the internal market and the monetary union. The possibility of competing in world markets depends on the capacity to demonstrate the superiority of European products and services with reference to their quality, design, innovativeness, and ability to satisfy the requirements of an ever-changing market demand. The greater quality of European products and services might give them the possibility of being competitive despite their cost, originated by high salaries and high standard of living within the EU.

A comparison between EU and U.S. economies [Stajano 2009] shows that, even though European industry is behind U.S. in key sectors linked to the new economy, it is successful in other sectors, including some high-tech sectors. It is primarily in mature sectors that the European industry beats the U.S. competition. In most cases the competitive advantage derives from quality rather than price. However, the challenge for the European economy does not come only from the U.S. Analyzing the world economy, we noted elsewhere [Stajano 2009] that emerging countries, and particularly the BRIC*K*s (Brazil, Russia, India, China, and *K*orea), are growing in importance and are overthrowing the economic and trade relationships. In addition, a new phenomenon is changing the market demand worldwide: an ever growing number of price-conscious customers value *good enough* products better than *best* products, if sufficient quality is offered at budget price [Christensen 2002, 2003].

That large part of the European industry that has acquired a leading position in the international markets in those sectors where the technological challenge has been less aggressive will have to face a new form of competition, in which the maintenance of the competitive advantage will depend on the capacity to integrate innovative content into processes, products, and services. In these sectors ─that include those producing household appliances and cars─ a strong competitive offer from the emerging countries is present. The EU industries will be able to maintain their competitive position only by increasing high-tech content and innovation.

On the other hand, those companies that have acquired a leading position in the international markets for complex technological products (aerospace, transport, chemical

sectors) but that are highly dependent on the acquisition of patents and licenses will have to face new challenges linked to the acceleration of the innovation process and the consequent difficulty in offering products with the most advanced technological content without having an endogenous innovation capability.

In the EU member states where enterprises have low innovation propensity, signs of decline have already been apparent already before the 2008 crisis, and negative effects with decreasing market shares were visible on low-tech activities, too. Because of the ubiquity of technology, a competitive advantage is linked to the introduction of advanced technology also in products and services traditionally considered low-tech (e.g., ceramics, textile industry, shoes, furniture, and tourism). Even low-tech products benefit from high-tech processes used to manufacture or to market and service them.

The EU, in order to maintain its share in the global market, ensure sustainable growth and employment, and face the knowledge-based society, should invest in education, training, lifelong learning, research, and innovation; and improve ITC infrastructures, diffusion, and literacy.

In this paper we prove that research policy played (and is playing) a very important role over and above the institutional objective of competitiveness: the research policy contributes to the achievement of the political union, to the implementation of other policies, and to the irradiation of European values within and beyond the European boundaries.

The Treaty on the EU states that EU research shall encourage EU industry to become more competitive and strengthen its scientific and technological bases by achieving a European research area in which researchers, scientific knowledge and technology circulate freely. Research policy for competitiveness cannot be implemented at member state level, since its success depends upon the complementarities and synergy across the Union. Research projects involve undertakings from different member states and create a network among the most creative, innovative, and productive scientists, industrialists, and firms in the participating countries. They extend a collaboration that for centuries had connected the great European universities ─nodes of a network of exchanges and of philosophical, legal, and scientific collaborations going on even when Europe was ravaged by wars that left nothing but death and destruction in their wake.

A real EU research and technology policy was formalized only in the mid-1980s [Stajano 1999] with the reform of the Treaty of Rome through the Single Act (1987). However, soon after the end of the Second World War (1940–1945), some European countries had already joined forces to create CERN (1953), the international laboratory for high-energy physics research; and in 1957, at the same time as the Treaty of Rome, the six founding members of the EEC signed the Euratom Treaty for the peaceful use of nuclear energy for the power plants required by the industrial reconstruction of Europe. Other signs of a Community research policy beyond Euratom can be traced back to the 1950s, even though the policy was limited to agriculture and the sectors linked to postwar industrial reconstruction.

A new approach to research policy and to the role of research in industrial development was suggested in 1979 by Etienne Davignon, the European Commissioner for Industry. He entered into negotiations with the 'Big 12 European information and communication technology (ICT) companies' to see whether it would be possible to

ensure a world market share and competitiveness for the European ICT industry. Davignon's vision started a synergic process at the intersection between research and industrial policy and generated a new spirit of participation and cooperation within Europe.

The experience of Euratom had taught Davignon a lesson. Euratom had been set up as a research center of several thousand scientists meant to support energy production from nuclear fission to satisfy the energy requirements for European reconstruction and development. In a spirit of nuclear optimism and under the pressure of the lobbies of U.S. technology providers, the nuclear industry was presented as a mature sector requiring only the construction of nuclear power stations rather than preliminary research on plant safety and waste disposal. European policymakers did not take into account the energy market trends, the prospecting for new oil fields, and research on new energy sources, or consult the European companies that would build the nuclear power stations or the utility companies that would manage the distribution and supply of energy to the end user. The combination of the reduction in oil prices owing to the discovery of new oil fields, a new environmental awareness, environmental movements, and nuclear safety problems led many European governments to reduce or ban nuclear production programs in the decades following the start of Euratom. This situation caused a long period of decline for the organization. Euratom, which represented a top-down action taken by eurocrats and member states' governments under U.S. pressure without any expert advice or market research, was a stronghold of highly specialized and highly paid officials with open-term contracts and limited professional mobility. When, after a few years, it became clear that the project was no longer meeting EEC priorities, the European Council could not dismantle Euratom, due to pressure from the trade unions and from the government of the hosting country. So Euratom survived as a plethoric, sclerotic, expensive, rigid, and obsolete structure searching for its raison d'être [Guzzetti 1995, Stajano 2009]. Learning from this experience, Commissioner Davignon unified under single management the industrial policy and EEC-funded industrial research putting industry center stage in the planning of the latter. He negotiated with the Big 12 companies, which were fiercely competing against each other in the market, with a view to creating a common space of precompetitive and prenormative cooperation in order to reduce the technology gap, prepare future industrial developments, stop the brain drain from Europe to the U.S., overcome the national champions policy of the member states, and create synergies between European research and European industry. The new attitude inspired industrial cooperation within Europe in the following years and was instrumental in supporting the establishment of the internal market.

Commissioner Davignon's contribution was twofold: on the one hand, he acknowledged that the European users of ICT technologies were the captives of proprietary systems binding them to their U.S. providers; on the other, he managed to reconcile the competition policy with the public financing of industrial research activities by defining a space of precompetitive cooperation. He aroused the interest of European industry's leaders in creating, together with their European competitors, the conditions for being successful in a market dominated by U.S. oligopolies while preserving the identity and independence of every single actor and promoting competition among these actors in a market now open to new entries.

The Big 12 companies were asked to draw up, together with the Commission, a strategic R&D program that would associate them with each other, with other European industries, and with European universities in order to achieve three objectives:

1. the development of standards of European origin to allow new actors to enter the market, to offer open structures and interoperable systems, to overcome the domination of the U.S. technological oligopolies, and to exploit the potential capabilities of the European industry
2. the development of a technological base for the growth of European industry
3. the creation of synergies between industries, universities, and research centers throughout Europe

The vision of Davignon contributed greatly not only to strengthening EU industry, but also to cohesion and integration of the member states, by overcoming the practice of protecting national champions and introducing the conditions for the buildup of European industrial multinational undertakings capable of competing internationally, for example, in the sectors of aerospace (e.g., Airbus, ESA, Galileo); production and design of microprocessors (e.g., ST-Microelectronics, ARM); microprocessor cards (e.g., Gemplus); software development (e.g., SAP); media and content industry (e.g., Philips, Giunti Interactive Labs); and of telecommunication technologies and services (e.g., Nokia, and numerous mobile service providers).

The consultation with the Big 12 marked the beginning of the European Strategic Program for R&D in Information Technologies (Esprit). Esprit was a 50–50 shared-cost program with industrial partners from at least two member states in which both small and medium-sized enterprises and universities or research centers could participate. The intellectual property regulations within the research contracts allowed each partner to commercially exploit the results achieved and to have access under fair conditions to the background information on the research subject under study that, before the beginning of the collaboration, belonged to the other partners.

The Esprit model was studied and applied in the U.S. and in Japan for their national research programs funded by public money. The main features that contributed to the success of Esprit and to its impact on competitiveness were: the inherent international structure of its consortia; the involvement of all actors in its strategic planning; the focus of funding on strategic priorities; the strong and effective monitoring of its execution; and the multiplying factor in exploitation of results originated by the sharing of IPR on results among all partners in each consortium.

Esprit and the other industrial programs delivered in at least three areas: standards, technologies, and networking. The standards of European origin set the EU industry free from the foreign IT oligopolies, opened the IT market to new entries – including small and medium-sized enterprises (SMEs), and paved the way to new business in mobile communication, multimedia, and the content industry. The EU industries participating in the programs achieved important technological results that have been integrated in systems and applications and created the conditions for the development and success of new processes, new materials, new products, new companies or the transformation of existing companies. Not least, the programs networked the European industrial and scientific community, creating synergies and collaborations

across the member states and building a European industrial research community. It is a very widespread and top-quality community, proven and reinforced by hundreds of thousands of person-years of transboundary research collaboration, which has allowed scientists, industrialists, researchers, and Ph.D. students of different EU countries to get to know and respect each other and to exchange new ideas and experience in a climate of intellectual and technological competition and in a context far from their daily routine, in which new ideas can be conceived and implemented.

Commissioner Davignon's successful action led to an important transformation of the role of research within the European Community, with the consequent harmonization of all Community funded R&D under the Framework Program. Associating over the years competitiveness with other policies, the EU put R&D center stage in policy making and justified a significant increase in R&D Community funding [Peterson et al. 1998] that rose from € 800 million per year in 1984 to over € 7 billion per year from 2007. The total R&D investment is almost twice this sum, since the EU is contributing in most cases with 50% of actually incurred costs, while the remaining 50% is contributed by the participating partners. At company level, the EU Framework Program allows a firm to take risks that it otherwise could not take by using its own skills and resources and leads industrialists and researchers to think outside the box in an open confrontation far from the direct control of their daily working environment. At Community level, research programs play an important role in the institutional transformation and cohesion between member states, and contributed to the development of the European Economic Community into the European Union.

In the years following the Esprit pilot phase, consultation and planning involved other operators in addition to the Big 12, so that, over the years, the number of subjects involved in R&D planning grew from the initial 12 participants to some thousands: SMEs, technology providers, users, system integrators, service providers, researchers, and public administrations. From bridging the technology gap and diffusing technologies (1983) the Framework Program moved to aggregation of firms and to coping with Japanese competition (1987); then the focus was on user-supplier collaborations, best practice and dissemination; and contribution to other Community policies than competitiveness, such as internal market and employment. By involving ICT users, this new orientation of the program promoted the spread of automation processes in public administration and industrial sectors whose core business was outside the ICT and contributed to achieving competitiveness and growth objectives by accelerating innovation and marking the shift from technology push to user pull, in response to the demands of a society in transition (1994). The following refocusing was on socio-economic values, support of SMEs (1998) and best support the industry competitiveness; the establishment of the European Research Area (ERA) and the building of the knowledge-based society (2002); until the present seventh Framework Program, planned as the research instrument aligned with the 2007-2013 financial perspectives that supports the revamped Lisbon Strategy, relying on a 65% increase of R&D resources to unify competitiveness and cohesion policies towards the achievement of sustainable growth. At company level, the EU Framework Program allows a firm to take risks that it otherwise could not take by using its own skills and resources and leads industrialists and researchers to think outside the box in an open confrontation far from the direct control of their daily working environment. At Community level, research programs play an

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In the year 2000, the European Union realized that her prosperity was dependent on the ability to face the challenge of the knowledge-based society and formulated the Lisbon Strategy (LS), a move with a view to boosting sustainable growth by building in Europe the most competitive economy of the world in the knowledge-based society. The Lisbon Strategy was seen by the EU in the year 2000 as the 1960s U.S. project *'the man on the moon,'* namely as a challenging and evocative mission that might mobilize energies and consolidate the enlarging European Union. The Lisbon Strategy became the umbrella under which all actions towards sustainable growth and increased competitiveness would fit, hopefully overcoming the shortcomings of horizontal cross-policy coordination and of harmonization of vertical levels of governance. This caused a lack of focus whereby the implementation of the strategy suffered.

Research and development policy was put at the heart of the Lisbon Strategy to boost employment and growth in Europe. Research, with education and innovation, was meant to form the 'knowledge triangle', which would allow Europe to maintain its economic dynamism and social model. R&D and innovation in the Union should be increased with the aim of approaching 3% of GDP by 2010. Two-thirds of this investment should come from the private sector [EC 2002-1].

However, the move started with the wrong foot, as a dirigistic project, as if the successful experience of the research programs initiated by Davignon in the 1980s had been in vain. The Lisbon Strategy suffered of major weaknesses: the lack of involvement of the stakeholders in its dirigistic conception; the lack of focus because of non converging objectives of all the policies involved; the lack of consideration of the East-West technological and industrial gap in the EU after the 2004 enlargement; and the lack of rewards to performing actors and sanctions to the member states that would not align to the strategy's principles. The Commission made the same mistake with the Lisbon strategy that had been made 50 years earlier by not involving all stakeholders in the planning of Euratom, which caused its decline. The Lisbon strategy resulted in a top-down project conceived by the Commission staff, without industrial consultation or involvement of all European social partners and, therefore, without a feeling of ownership by anybody and most importantly by no industrial group. The lack of a feeling of ownership is ever so much relevant because one cornerstone of the LS is the objective to increase technological R&D to 3% of GDP, of which ⅔ should come from private firms. While member state administrations can inject financial resources into research centers and universities, they can only encourage private R&D expenditure with infrastructures and incentives. But private enterprises will not invest on a plan that they did not contribute to shape to their needs. The Lisbon Strategy might end up being only a recommendation without power of enforcement [Monti 2005] with no rewards for its followers and without sanctions against those that, at the receiving end, would not implement it. In a similar way, in another field, the economic ministers of defaulting member states tried to (and to some extend succeeded in) converting the Growth and Stability Pact into little more than a powerless recommendation. The partial results

achieved so far by the member states suggest that they are not moving cohesively towards the Lisbon strategy objectives [Stajano 2009].

The Lisbon Strategy had however, a very important role in putting R&D center stage in EU strategic planning for sustainable growth and in creating the conditions for the member states to decide in the European Council for a major increase of public spending on R&D, thus reinforcing the most effective component of the LS, namely the Framework Program built on strengths of proved effectiveness: the involvement of all stakeholders in its planning, the feeling of ownership by the scientific/industrial community, focused funding, strict monitoring of execution, and enhanced exploitation plans.

The industrial research community has innovated not only the technological base, which is essential for competitive growth, but also the world of ICT users, thus preparing the Union for the information society and expediting the convergence processes in communication, information processing, the content industry, and the media. Research has achieved important technological results that have been integrated into systems and applications and have created the conditions for the development, transformation, and success of the companies involved. The process initiated by the Framework Programs is a catalyst for innovation inside companies and is particularly important not only for its visible, successful results but also for the transformation that it triggers in individuals, companies, and countries involved.

The results of EU-funded research are beyond counting and of very different nature: ideas, standards, technologies, patents, components, materials, processes, systems, applications, and networking of people and of firms, to name a few. A study by Muldur et al. estimates direct return on research investments to be three to fifty times after 25 years and quantifies in € 200 billion/year the return on FP7 investments by the 2030s [Muldur et al 2006]. However, many results ─and not the least ones─ are intangible and have to do with the transformation of the people, enterprises and countries involved. Results are integrated into solutions to the problems of society in any sector. We are interested here in identifying the impact of EU R&D on other EU policies than competitiveness: Agriculture, Audiovisual, Cohesion, Competition, Consumer Protection, Culture, Economic and Monetary Affairs, Education, Employment and Social Affairs, Energy, Enlargement, Enterprise, Environment, External Relations, External Trade, Fisheries, Food Safety , Foreign Policy, Fraud, Information Society, Institutional Affairs, Internal Market, Mobility of the Workforce, Public Health, Regional Policy, Taxation, Training, Youth, and Transport. An impact can be documented in each of the above areas [Stajano 2009]; we will expand here only on some of them.

Cohesion Policy: Research Policy is an instrument for cohesion: while the milestones of the new treaties marked the institutional evolution of the European Economic Community towards the European Union, European citizens, and particularly researchers, scholars, industrialists, and students, became ―through the initiatives of the EU research programs―, more and more aware of belonging in a borderless community much wider than their own country. This community has been working in an active and peaceful environment for Europe's economic, social, and political integration. EU research programs led to an upgrade in the scientific, cultural, and technological level of the participants promoting integration and cohesion. EU research programs have also promoted industrial partnerships and mergers between European companies, which have

lead to greater competitiveness and cohesion. Diversity across member states makes integration and cohesion complex and introduces additional costs to international cooperation, but it is an asset and a point in favor of the EU within the Triad. It facilitates addressing and understanding competitors in a world where new actors from remote markets and with different cultures take increasingly relevant roles. Community funding was the incentive to face the intrinsic complexity of international collaborations, an incentive ever so much important in EU27 to overcome the increased diversity in business culture, business practices, innovation, workforce qualification —including language fluency— across the enlarged Union.

Internal Market and Competition Policy: R&D helps the Internal Market and Competition Policy by overhauling the national champions' policy, removing non-tariff barriers, networking people and businesses across member states, and harmonizing standards. The standards originating in Europe protect the potential of the European industry and represent one of the necessary elements for the creation of the internal market. Vertical collaborations between operators acting at different stages of the value chain started from research collaborations, and often created stable industrial partnerships, synergies, and mergers, thus creating an industrial structure suitable for the EU single market under the rules set by the competition policy. Some successful multinationals (e.g., ST-Microelectronics) are the result of research collaborations; many other precompetitive partnerships have created a suitable space for the growth of the European industry.

SMEs —a vital and essential part of the economy of almost all EU countries— are often unable to directly invest in research because of their reduced dimensions; however, their competitiveness must be assured through appropriate actions to ensure their initiation into technology and the sharing of innovative experiences. In some cases, SMEs specialized in fast-developing sectors are at the cutting edge of research and, through industrial collaborations and subcontracts, provide the skills required for the innovation of big companies. National and international synergies among SMEs, collaborations between large and small companies, best practices and benchmarking were an important part of the R&D programs and a step in the quest for competitiveness contributing to the buildup of the internal market.

Research collaborations have contributed to the removal of nontariff barriers that prevented the realization of the internal market and have promoted a dynamic adjustment of the European industry towards the highest quality levels. These changes have occurred both through research collaborations and through the best practice sharing and benchmarking. A bottom-up transformation of the European industrial sector has thus occurred, characterized by: the most innovative countries and companies set the pace of innovation, the de facto standards, and the competition rules; competition is no longer based on price but on quality; market segmentation is no longer based on the geographical origin of products but rather on their functionality, quality, and performance.

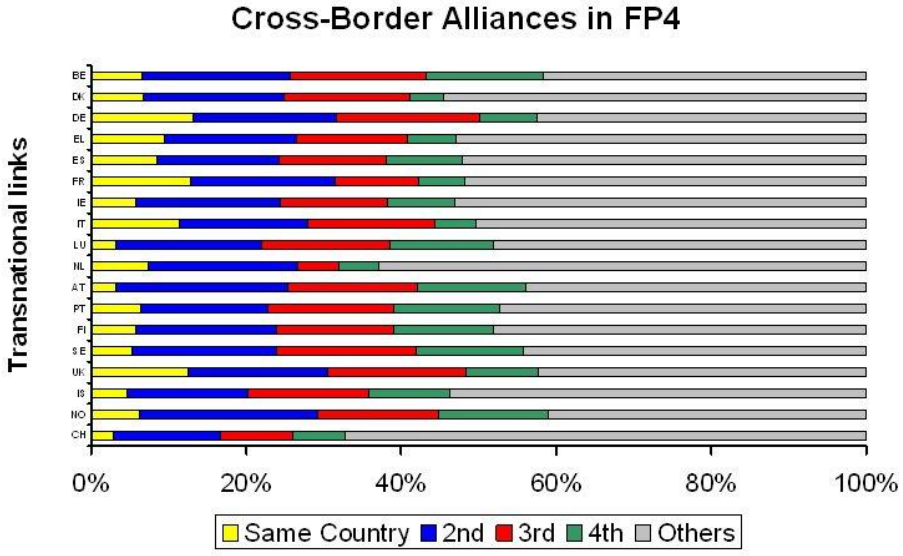
Other factors resulting from research programs that accelerated the creation of the internal market have been: the mobility of workers, particularly of researchers and Ph.D. students; the harmonization of standards in design, workers' performance and safety, and,

above all, in interfaces; the diffusion of open and compatible architectures in which heterogeneous multivendor systems can successfully cooperate.

Enlargement: R&D helps the Enlargement Policy by associating candidate countries to R&D programs, creating scientific as well as business links with member states, and preparing for further integration. Cultural, scientific and research collaborations can be established much earlier than trade agreements, custom union, defense alliances, and common foreign policy, while preparing for these further steps towards integration. Since the 1980s, the association to R&D programs of undertakings from future enlargement countries with EU firms triggered transnational industrial partnerships and has favored the integration of those countries, the spread of European values and the harmonization of business practices. R&D programs have involved and still involve participants from countries that are about to become members of the EU: for example, Portugal and Spain at the beginning of the 1980s, the East German regions after the fall of the Berlin Wall (1989), the member states of the European Economic Area (EEA) at the beginning of the 1990s, the central and eastern European countries (CEEC) since the mid-1990s, and currently the three candidate countries (Croatia, Macedonia, and Turkey). In the past 10 years, the Framework Program has promoted the participation of third countries, involving the participation of undertakings from over 100 countries. This action is funded with just 2% of the FP budget, but has relevant impact on the EU relations with the rest of the world, contributing to her foreign policy and irradiating European values internationally while preparing for long term commercial and political collaborations. Research programs have created a community of scientists, industrialists and researchers united in temporary and voluntary associations based on common development objectives. These associations have often defined the rules for integration on an industrial scale rather than just at the level of research. Working together and with the help of EU funding, some partnerships have been created from the bottom up and have contributed to the implementation of an EU-wide process of innovation and cohesion that has proven to be much more effective than any top-down action. The knowledge network and the awareness of the existence of qualified subjects in several industrial sectors have been the basis for a structural change in EU industry contributing to bridging the gap between ‘old’ and ‘new’ member states. The contribution of the research programs funded within the fourth Framework Program (FP4, 1994–1998) to the internationalization of industrial partnerships is shown in Figure 1. For each EU and EFTA state, the rate of national and transnational partnerships is indicated. As can be seen, even in the biggest European economies (Germany, France, the United Kingdom, and Italy) the rate of national partnerships is at most 13%, which means that at least 87% of research partnerships involve industries or universities or research centers of other states. Transnational partnerships represent a golden opportunity to start collaborations and processes of mutual knowledge and sharing of experience and skills that can change the European industrial framework and narrow the gaps between the member states. Links formed in projects persist beyond the initial R&D cooperation and may move from the lab to the board room, creating alliances and mergers.

Employment: R&D helps the Employment Policy by creating new businesses that generate jobs, qualify the workforce, and facilitate mobility. One of the most important results of EU research over the past 25 years has been the creation of open architectures and the reduction of the technological gap between the EU and the U.S. EU action to

define interoperability platforms and create open systems has allowed new operators, particularly SMEs, to enter the ICT market, thus overcoming the dependence of the European information technology industry and information users on the foreign oligopolies that dominated the European market until the end of the 1970s. Standardization in data transmission, document architecture, image coding and physical and software interfaces has opened and widened the market. Standardization supported the competition policy by opening markets to new actors and helped the employment policy by creating new business that generated jobs by the million in mobile communication and services, content industry, and multimedia. The participation in research projects with the best international partners has exposed European industrialists to best practices and contributed to the qualification of the best part of the workforce.



SOURCE: European Commission Science and Technology indicators 1997.

Figure 1. Transnational alliances initiated by R&D contracts in FP4. This figure presents for each EU and EFTA state the percentage of research contracts with undertakings in the same country and of contracts with foreign ones. The first area in each row represents the percentage of research alliances within the same country. The following areas in each row represent the percentage of research contracts between undertakings in the country named in that row and undertakings in a given EU or EFTA country. Most frequent partnerships are with the UK, France and Germany.

Institutional changes: The implementation of the research policy has anticipated institutional changes and widened the EU's scope. As an example, in the quest for strategic technological development in the interests of the Union, beyond the specific interests of individual countries, decisions on specific programs were at times made in the early 1990s with qualified majority voting prior to the enforcement of this rule following the Treaty of Amsterdam.

Environment: R&D helps the Environment Policy by supporting the EU and the member states in taking informed decisions on ways to preserve the environment and protect human and animal health. From the very start of Esprit, the sub-program 'Computers in Manufacturing' addressed in the early 1980s the challenge of clean

manufacturing to contain the environmental impact of industrial processes. In the last 25 years, the Union has broadened her attention to environment by supporting a great number of projects to learn more about connection between industrial development, urbanization, and pollution, with particular attention to the greenhouse effect and global warming. A major objective of European research is to improve models that predict how global environmental change will affect various parts of the planet. Every possible avenue must be explored. Researchers are examining ice and sediment cores to try to understand how the earth's climate has changed in the past. Various projects are looking at the effect that climate changes might have on Europe's water resources and are collecting information on water reserves to build a scientific base for policies aimed at helping the more vulnerable areas to cope. At a local level, many projects are monitoring coastal areas that could be affected by a rise in sea level or an increase in the frequency of severe storms. Researchers are also studying processes of erosion and desertification to find out how these might be slowed down [EC 2003-1].

Energy: R&D helps the Energy Policy with long-term project for preparing the medium and long term future. Renewable energies are centre stage as the European Union develops a new energy policy fit to ward off the potentially dramatic effects of climate change and reduce the EU's dependence on imported fossil fuels. A number of demonstration projects were launched under the Framework Programs: several projects have tackled two key challenges for concentrated solar power plants: improving operability and reducing costs [EC 2007-1].

Research into nuclear fusion is a 'long-term project' that may deliver exploitable results only after many more decades. Nuclear energy does not produce greenhouse gases and reduces energy dependence. Nuclear fusion would share those two advantages, and have the further merit of not producing long-term radioactive waste. Fusion therefore would offer very real benefits, which the European Fusion Development Association (EFDA) intends to make better known. Although construction of the International Thermonuclear Experimental Reactor (ITER) at Cadarache, France has begun, no one is yet suggesting that this source of energy, which in theory is both clean and inexhaustible, will have been mastered on an industrial scale before the end of the twenty-first century. ITER was set up by an international treaty signed in December 2006 between the EU, China, Japan, Russia, the United States, South Korea and India; the treaty, entered into force in October 2007 after ratification by the parties involved, is the biggest scientific collaboration of its kind. EFDA coordinates Europe's participation in the research that ITER conducts [EC 2007-1].

Transport: R&D supports the Transport Policy by helping Europe in developing a smarter, safer, cheaper, and greener multimodal transportation system. Efficient road transport is a fundamental requirement for sustainable wealth and prosperity in Europe. Transport drives employment, economic growth and global exports. It provides European citizens, societies and economies with essential resources and means of mobility, while acting as a catalyst to European integration. Road transport also drives new job creation. Indeed, it is one of the most important job-creating sectors, providing work for young men and women all over Europe. All of this makes transport a cornerstone of the European Union's growth strategy. But the increasing demand for mobility also represents a major challenge. Rising levels of road traffic and congestion are accompanied by increasing safety and health concerns. The environment can suffer due

to transport activities, and transport networks require frequent maintenance and upgrading. In some cases, radical solutions are required, highlighting the essential role of research. Road research moves Europe forward in a number of different ways. First, it leads directly to new products, processes and services, improving industrial efficiency and providing a competitive edge for Europe in the global transport market place. At the same time, it addresses infrastructure, mobility patterns and human factors that are specific to Europe itself, helping to improve the daily lives of ordinary citizens by making transport on our roads. Areas covered by EU funded research in this domain include: city logistics, safety, road infrastructures, alternative vehicle concepts, and transport noise [EC 2005-1].

Research efforts are guided by the Intelligent Car Initiative. Over € 400 million have been invested in intelligent-car-related research over the last eight years. Building on results from previous programs, the Initiative will foster cooperative research in Intelligent Vehicle Systems (IVS) and help facilitate the take-up of research results. Specifically, this will include: driver assistance systems, vehicle-to-vehicle and vehicle-to-infrastructure communication, real time traveler and traffic information, and intermodal transport [EC 2006-3].

Consumer Protection: R&D supports the Consumer Protection Policy improving the health and wellbeing of European citizens. Quality assurance and the prevention of fraud are crucial to both local consumer protection and the maintenance of international reputation of European food products. The food quality and safety program has the aim of improving the health and wellbeing of European citizens through the improvement of the quality of the food that reaches their tables. The program also addresses the improvement of food production control and increased observance of environmental factors linked to food production. In the food chain, priority is given to safeguarding consumers and their demand by assuring healthy food with high-quality organoleptic and nutritional properties [EC 2003-2]. Research related to this sector is not only based on traditional disciplines such as zootechnical and agricultural production, control of industrial processes, nutritional sciences, and chemical and biological analysis techniques, but also on new information from genomics, medicine, biotechnology, ICT, environmental sciences, economics, and social sciences. The main objective of this research is the human aspect of nutrition, but it also addresses zootechnics, animal feeding, food packaging and conservation, distribution, health, and ecological risks connected with the food chain [EC 2007-3].

Enterprise: R&D supports the Enterprise Policy by enhancing competitiveness in the industrial and services sectors, maximizing the potential of the internal market, and promoting entrepreneurship and innovation. The goal R&D in the area of the enterprise policy is to help create an environment in which firms can thrive, thus creating productivity growth and the jobs and wealth necessary to achieve the objectives set by the Lisbon Agenda concerning competitiveness, innovation, and entrepreneurship. Most research actions in this area belong in the Information Society Technologies subprogram. Some examples follow: many small industries do not have the resources to contribute to the innovation process but can take advantage of new technologies of proven effectiveness by means of an action addressed to novices. This action (First User Action

or FUSE) assists enterprises during their technological initiation and proves to them that the use of ICT can result in significant economic advantages; the economic and social importance of the small-sized food trade has led the Union to finance research to define space in the food market for small shops that have to compete with large supermarket and hypermarket chains [EC 2007-2, EC 2007-3]. A very important outcome of R&D programs in the area of the enterprise policy is originated by the networking of European industries through the planning and execution of research projects: successful synergies experienced in the research labs created the condition for industrial alliances and mergers, introducing the conditions for the buildup of European industrial multinational undertakings capable of competing internationally and thus contributing to the solution of a major European problem, the fragmentation of the industrial fabric in small and micro enterprises.

Information Society: R&D supports the Information Society Policy by delivering cutting-edge science and technology in all areas of society. Although the Information and Communication Technologies (ICT) sector is itself worth 6 to 8% of the EU GDP, ICTs importance goes well beyond that since they are vital to: meeting the globalization challenge by boosting innovation, creativity and competitiveness through their ubiquitous presence in all economic activities; delivering in all scientific and technological areas; making Europe's large public sector more efficient, and modernizing sectors ranging from education to energy; tackling social challenges, improving quality of life and meeting the challenge of an ageing society. Europe must therefore master these technologies to remain competitive and safeguard its quality of life, which justifies the high ITC investment in FP7 [EC 2007-2].

Information and communication technologies evolve rapidly and are creating such a significant transformation in the economy and society that it can be described as a third industrial revolution, following the first one caused by the steam engine in the eighteenth century and the second one brought about at the beginning of the twentieth century by the industrial and domestic use of electricity, phones, and cars. One of the differences characterizing the new society is the change in primary resources required for production, which is no longer just energy and raw materials, but includes information structured into knowledge to the service of high quality developments and improved processes. The new challenge for the modern firm lies in the capacity to manage the information overflow and to structure information into corporate knowledge, its edge over its competitors.

The information market creates new professions and new jobs in a context where competition is strong and where new actors are appearing on the scene from emerging countries. Promoting precompetitive research and creating pilot and demonstration projects, the European Union establishes herself as one of the main producers of basic technologies, applications, and their multimedia contents. The Union also promotes standardization in ICT, which broadens the market and allows the entry of new actors, reinforcing the potential of European industry [EC 2006-2, Stajano 2009].

Health: R&D helps the Health Policy exploring new avenues in curing and preventing human illness and diseases and identifying health hazards at work and sources of danger to human health. Under the Treaty, EU action must aim to improve public health, prevent human illness and diseases, and identify sources of danger to human health. This has led to integrated health-related work at EU level, aiming to bring health-related policy areas together. Through the health strategy, the EU plays its part in

improving public health in Europe, and in so doing provides added value to member state actions while fully respecting the responsibilities of the member states for the organization and delivery of health services and health care. Health and consumer protection policies are particularly closely linked. The safety of products and services — including food safety and rapid food alerts— are key priorities.

Conclusion

Research policy strengthens the scientific and technological base of EU productive activities, is a catalyst for sustainable growth and qualifies the workforce. Its results are beyond counting and changed in 25 years the industrial and academic European scene. R&D has a high return on investments in the medium term, but research policy beneficial effects are not limited to its institutional goal of competitiveness and wealth creation: it also contributes to the realization of other EU policies: internal market, competition, enlargement, environment, employment, transport, energy, health, consumer protection, cohesion and integration of member states, institutional transformation, and ─not least─ the perception by the European citizens of the value of Community actions: scientists and researchers are responsible for getting the record straight showing what science and research in Europe can really bring to European citizens [Claessens 2007]. Changes triggered by research policy are bottom up and affect people in the first place: researchers, industrialists, students. By getting to know their peers in other countries, European citizens who participate in the programs learn to respect and appreciate diverse cultures, overcome the barriers that divided Europe in recent and remote past, experience the feeling of belonging in a larger community than their own country, and establish networks that are the ground culture for European citizenship. Changes triggered by research policy affect enterprises as well. They broaden their horizon and they experience the advantages of that international collaboration that had been known to universities for centuries. This bottom-up action complements and is supported by the institutional activities of the European Union and builds a community *united in diversity* capable of facing the challenges of the globalized world.

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