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Policy Review Series n°7

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EUROPEAN COMMISSION

EU RESEARCH IN SOCIAL SCIENCES AND HUMANITIES

Policy Synthesis of EU Research Results

Series n^{o} 7:

Research, Innovation and Technology Policy

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2007

Directorate-General for Research
Citizens and Governance in a Knowledge-based Society

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Luxembourg: Office for Official Publications of the European Communities, 2007

ISBN 978-92-79-07572-8

Printed in Belgium

PRINTED ON WHITE CHLORINE-FREE PAPER

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FOREWORD

The policy review series aims at synthesizing results of research projects funded by the Community's socio-economic research programmes, and drawing their implications for policies in particular domain. It is part of an increasing effort to valorize the results of that research and increase its impact on policy. This review is addressed to policy makers and other stakeholders interested in research, innovation and technology policy.

The added value of these reports lies in the consolidation of results and in the identification of key research and policy issues that emerge in the setting of European collaborative, and usually comparative, research.

Nikos Kastrinos
Science, Economy and Research
Directorate-General for Research

1 Executive Summary[1]

In between 1994 and 2004 the fourth and fifth Framework Programme (FP) supported a number of research projects to address various aspects of technological change and innovation and its consequences for society, economy and policy. Twenty of those projects were selected, on the basis of an initial appreciation of their potential, to be reviewed with the aim to highlight their implications for research, technology and innovation (RTI) policy.

The selection of projects reflects the current dominance, in innovation research, of insights from evolutionary economics, modern firm theories, institutional economics and the heuristics of innovation systems. These approaches provide the framework for empirical investigations which use a wide range of empirical techniques and data sources. In the documentation reviewed, the findings from these projects are, in general, well elaborated, and new perspectives are presented in a reflexive and discursive way. Although many such findings are well diffused within the scientific community, the translation of research insights into the practice of policy-making is still fragmented and somewhat lagging behind. The report tries to fill this gap by identifying the policy-relevant lessons which emerge when considering and contrasting the projects together.

Within the review the topics addressed by the projects have been clustered into five main thematic areas, namely:

- The impact of innovation: economic performance, employment and sustainability,
- The changing nature of knowledge production: organisational and spatial dimensions,
- The importance of institutions: between harmonisation and diversity,
- Human capital, labour market and innovation: the role of the individual, and
- The governance of research, technology and innovation policy: rethinking the role and the processes of political decision-making.

These five broad themes not only emerge as central across the projects reviewed, they are also crucial for addressing the main challenges Europe is facing at the moment and which are captured in the (revised) Lisbon objectives as follows: to become "… the most dynamic and competitive world region" and "...to create more and better jobs…". In line with this general political ambition three more specific aims can be pointed out, that need to be tackled in the coming years and to which research and innovation policy are expected to deliver major inputs: i) enhancing competitiveness and innovation, ii) creating employment, iii) ensuring sustainability, and iv) ensuring legitimacy for RTI policy.

Set within this context, three main conclusions of the review can be highlighted. First, the projects deliver vital, often new, insights into the nature of innovation processes, often through comparing different regions, countries and sectors. This must be seen as an important value added of the projects funded under the FP. They show that a more differentiated perspective on innovation systems and on research and innovation policy is needed to exploit the innovation potential of Europe and to avoid counter-productive effects from excessively generalised policies. Significant results are also delivered with respect to the globalisation strategies of multinational firms, the role of institutions and the impact of innovation on performance, competitiveness, and employment. Moreover, the projects address the growing importance of services and the associated structural change in manufacturing industries as well as the greening of industry and movement towards sustainable development.

Secondly, the projects under consideration deliver new empirical insights on the strengths and weaknesses of the European Innovation System and its preparedness for coping with the new challenge of the knowledge-based society. Most striking is the observation that Europe performs less well in "new sectors" as compared to established ones. The projects stress to understand better the institutions that contribute to technological competitiveness and innovation output. The projects thus allow the identification of major barriers and bottlenecks that prevent Europe from exploiting its potential. These are rooted partly in a lack of strategic orientation and competencies within industry, in particular with respect to organisational innovation, but also inflexibility in large segments of the institutional framework: industrial relations, educations system, knowledge transfer form academia to industry, intellectual property rights (IPR) regimes, and finally deficits in policy formulation and implementation itself.

Thirdly and finally, based on the rich material reviewed important directions for policy emerge which clearly show the need for increased co-ordination and participation within an increasingly complex policy landscape within Europe:

- *Strengthening unique combinations:*
  RTI-policy in Europe has to be guided by the notion of "building unique combinations". This requires to build on existing strengths, but also to exploit their combination with new emerging developments in science and technology, which in turn requires maintaining Europe's diversity in research, innovation, and institutional arrangements.

- *Ensuring harmonisation to complement diversity:*
  In spite of this quest for diversity, it is also necessary to improve harmonisation within a European Innovation System with respect to the basic institutional settings that provide the infrastructure of innovation and that ensure the creation of large common markets. Europe needs to combine some harmonised institutional arrangements at European level with a great deal of institutional diversity at other levels, it is crucial to identify those aspects that should be tackled in a harmonised manner. Exploiting these specific conditions requires a "European way of RTI-policy" rather than copying models from overseas.

- *Delivering the institutional basis for variety creation:*
  Universities and Public Research Institutions are major knowledge sources in innovation systems and significant factors in decisions of large and small firms to invest in a specific location. It is essential to encourage the emergence of novel ideas and at the same time ensure that they are rigorously subject to scientific quality standards in order to generate robust knowledge on which to draw for purposes of innovation. In order for these functions to be provided effectively, scientific autonomy and institutional flexibility are necessary as well as incentives to explore new ideas and bring science to bear in practice.

- *Supporting organisational innovations:*
  Organisational innovations are necessary for companies and public bodies in order to unlock the full potential of new scientific discoveries and technologies. Institutions like the training system, trade unions and so on have to play a more prominent role in enabling the exploitation of innovative sources. Firms need to be supported to absorb and use external knowledge and learn how to make use of the potential of intangible assets and investments.

- *Stimulating product and radical innovations:*
  If innovation is to increase employment, research and innovation need to be supported in sectors that are characterised by a potential to lead to product innovations and radical innovations. Thus, policy has to focus on industries with high rates of product innovation such as knowledge intensive business services (KIBS) in order to foster employment creation. For innovation policy measures to be supportive of employment goals policy has to take a long-term view, and overcome trade-offs with short-term goals which are often guided by strong interest groups or lobbies.

- *Improving coordination of RTI-policy:*
  There is a growing demand for coherence between industrial, RTI-, education and macroeconomic policies, as well as between RTI-policy and sectoral policies, both at individual policy levels and between them.

- *Strengthening participation in RTI-policy making:*
  The processes leading to the definition of RTI policy are being reconsidered in the light of the governance principles as set out by the Commission, and this upgrades the role forward-looking approaches to policy. At the same time there is a growing scepticism with respect to the ability to anticipate the impacts of targeted policy interventions, favouring participatory approaches to policy-making processes in general and foresight in particular.

It is important to note that the fact that policy directions like those above, emerge from a set of research projects does not mean that all the questions have been answered. The development of policy-relevant knowledge points towards new sets of problems to be solved and areas of knowledge to be developed. Important future research directions emerge in the interplay between organisations and institutions, the balance between harmonisation and diversity, the operation of effective mechanisms to enable goal-oriented transformation processes, and the heuristics and rationales (rather than just tools) for the assessment and justification of policies for employment and sustainability.

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[1] The authors would like to thank Ken Guy, Nikos Kastrinos and Klaus Kubeczko for their valuable comments, suggestions and contributions to the review.

2 The changing policy environment

In the last years the nature of technological change, research and innovation has been changing quite significantly and brought about new challenges for industry, policy and society at large. The innovation process has to be considered as a learning and competence building process where many actors are engaged in a complex way of interaction and knowledge transfer. Empirical findings confirm the growing importance of *investments in knowledge and information and communication technologies* (ICT) and of the *internationalisation of research and innovation* performed by companies. *Multinationals* (MNCs) play a key role for shaping and organising research and innovation processes, a development that stresses the importance of regional and cultural *location factors* for innovation and investment in R&D.

Of utmost importance is also the perception that the *pace of change* has accelerated, imposing high requirements in terms of knowledge and flexibility on individuals, firms and governments. This move towards a knowledge society - as it is sometimes called - in its various facets has been the subject of a large number of research projects, both at national and European level. They have provided evidence of the process of change, aiming to systematize our understanding of the driving forces behind, of the likely impacts and of the possible strategies to cope with it.

The knowledge society promises major opportunities to sustain Europe's economic well-being and improve living conditions. However, it is a multi-facetted development that entails social and other risks. As a consequence, intense policy debates at national and European level over the past years have been dealing with this challenge. The emphasis has been put on making the EU "the most competitive and dynamic knowledge-driven economy by 2010" (EC 2000) and on creating "jobs and growth" (EC 2005c). The most recent strategy papers prepared on behalf of the European Commission indicate stress the importance of combining more investment in research and education (R&E) with the creation of innovation-friendly markets (Aho et al. 2006). However, in spite of the current prominence of growth, competitiveness and employment issues for the debates on research, technology and innovation, the concerns with the long-term sustainability of our societies have remained prominent in the political agendas (EC 2001b). Not least, the recent changes in the assessment of the security of energy supplies confirmed the need to enhance energy- and resource-(eco-)-efficiency (EC 2006). New technology and innovation are expected to provide contributions solutions for tackling these challenges (EC 2004). Far-reaching visions in a variety of technological fields such as nanotechnology, biotechnology and converging technologies, meet with split assessments: techno-economic promises are raised as well as severe societal and health risks.

Decision-making about these contentious issues is controversial. Policy-makers in the public and the private sphere are confronted with a high degree of uncertainty, complexity and ambiguity that cannot be resolved by recourse to scientific knowledge alone (Renn 2002). Against this background, debates about the governance of science, technology and innovation (RTI) policy and their embedding in society at large have become more prominent in recent years. Changes in the patterns, content and pace of knowledge production in a global context pose major challenges to industry and government. Four main challenges can be highlighted around which policy agendas have been gravitating in recent years, and are likely to remain of major importance for the years to come, though with varying levels of priority:

- *Enhancing competitiveness and innovation:* European policy document tend to reflect a constant fear that the EU might fall behind the US in *competitiveness*, and even worse, in

its ability to catch up. Fostering research and innovation is regarded as the decisive means to make Europe the most dynamic and competitive world region, as formulated in the Lisbon objectives (EC 2000). Related to the issue of Europe's global competitiveness, great hopes (as well as major fears) have been associated with the *accession of ten (or more) countries* to the EU and their full integration in the European economy and research and innovation area, by giving rise to the exploitation of potential synergies. However, in most accession countries, a major upgrading of the research and innovation systems is necessary in order to ensure that they can compete, not only temporarily on the basis of low wage levels, but also in a sustained way through an innovative and dynamic research base. The fear of falling behind is further fuelled by the apparent stagnation of R&D investment in Europe. The Barcelona targets were set to increase *R&D spending* and thus also accelerate the pace of innovation in Europe. The least they have achieved is to significantly boost attention for RTI-policy among policy makers at the national and European level. The emphasis on a major increase in input factors for research (R&D expenditures at 3% of GDP by 2010) is tied to the hope for a corresponding increase in the quantity and quality of innovation outputs, thus contributing to competitiveness, growth and employment. However, it will remain of utmost importance to continue to improve the structural and framework conditions in the national and European innovation systems (for instance with respect to science-industry relations, financing, start-ups, human resource base, etc.) to ensure that R&D investments can be effectively translated into innovative products and services (EC 2005a).

The 6th and 7th Framework Programmes are key levers of European policy to exert structuring and orienting effects, rather than simply a financial impact on the European Research Area. With FP6 the emphasis has been put on scientific excellence and on reinforcing large-scale initiatives of various kinds. In many respects it represents a departure from previous framework programmes that allowed for much more diversity in research to be created, a change that is not unanimously assessed in a positive way. FP 7 aims at correcting some of the problems while maintaining the general orientation of FP 6 (EC 2005b)

- *Creating employment:* Competitiveness and innovation do not automatically translate into employment. This is probably one of the key lessons of the past twenty years of research and policy making in Europe. This is why the re-launch of the Lisbon Agenda under the headline of "jobs and growth" marks a significant shift in attention. In the end, a highly skilled labour force is an essential pre-condition for leading edge research and innovation. Key issues in recent policy debates tackle the barriers to mobility of researchers in and beyond Europe, the orientation of our training and education institutions and of our universities in particular, or the rigidities imposed by the diverse labour market regulations in Europe.

- *Ensuring sustainability:* The Lisbon objectives put the emphasis on the social and economic dimensions of Europe's endeavour to become the most competitive world region. They were subsequently complemented by the statements of the Gothenburg Council (EC 2001b), which highlight the importance of making the environmental dimension a horizontal policy concern and make sustainability a third, complementary pillar of Europe's future economic policy strategy. The need to place the three dimensions (social, economic and environmental) at an equal footing has been reinforced recently by the growing concerns about secure supply of natural resources and energy in particular. Environmental considerations regarding eco-efficiency have thus re-entered the list of most pressing policy agenda items due to non-environmental concerns (EC 2006).

However, integrating all three dimensions of sustainability into the practice of European and national RTI-policy is thus expected to become a major challenge for the coming years.

- *Ensuring legitimacy:* Policy-making is confronted with major difficulties in designing, implementing and coordinating effective, coherent and credible policy initiatives. Such difficulties stem from the growing complexity of innovation processes, and have raised the profile of knowledge from systems-oriented innovation research. Due to the lack of clear-cut policy recommendations from such research, an iterative approach of mutual and continuous policy learning has been advocated. Such an approach has been institutionalised in the so-called "open method of coordination". In this context, the range of policies relevant to research and innovation has been broadened to include also sectoral policies (e.g. energy, transport, IST, environment, regional). Most notable in this context is the reinforcement of innovation initiatives in the European structural policy and the CIP-programme which aims to integrate several sectoral innovation policy initiatives in a kind of framework programme (EC 2005d). This trend towards more policy coordination and coherence affects not only horizontal relationships between policy areas, but also the coordination between different policy levels (regional, national, European, global) and the interactions between policy-making and various stakeholders (OECD 2005). The Technology Platforms that have been launched in the course of the last five years are but one indication of the willingness of the European Commission to give other – here mainly industrial – actors a voice in the definition of future research and research policy agendas. This participatory approach aims on the one hand to ensure an effective implementation of overarching policy strategies, but it is also a means for taking into account the societal perception of S&T-related risks, uncertainties and value judgements. Due to the controversial character of several technological opportunities, the need for wider participation in policy debates, transparency, accountability and effectiveness, especially at European level, has been called for (EC 2001a).

This report synthesizes findings from a set of European research projects, aiming to provide new insights on how to tackle these four challenges. While being inevitably selective, the synthesis serves to demonstrate what we have learnt about the changing patterns of innovation and the extent to which this knowledge can be brought to bear on policy. The next chapter will give a brief overview of the projects reviewed, followed by a sketch of the five clusters of themes that showed up most prominently in the research projects. Thereafter, the most interesting findings on the five themes will be summarised and discussed, on the basis of material from the twenty projects. Research questions, theoretical contributions, empirical findings and policy issues and implications will be introduced and commented upon. Each theme is structured in a few sub-themes, and specific policy issues and implications will be provided at the end of each thematic section. Finally, we look into the most interesting cross-cutting conclusions and requirements for research and innovation policy that could be extracted from the reports, but suggest also some areas where further research will be needed in the future.

3 Overview of projects reviewed

The twenty research projects reviewed for this report were funded by the respective socio-economic research programme within the fourth and fifth Framework Programme.[1] Twenty projects have been selected in co-operation between DG Research and the authors.[2] They deal with various aspects of technological change and innovation that have become important and entered the academic, public and policy agendas in the last few years, addressed from a broad socio-economic perspective, and their consequences for society, economy and policy (see Table 1). The projects tackle a broad spectrum of issues, ranging from globalisation and organisational change to the impact on sustainable development and the role of institutional frameworks for innovation. The projects were organised either as collaborative research projects or as thematic network involving researchers from many European countries and occasionally also researchers from overseas. Their outputs include publications (papers, and books) conferences, and internet pages. The projects rely on different, often similar theoretical concepts, combine different approaches and perspectives and use different empirical data, based on survey, existing databases and case studies.

The target audience of this report is the research, technology and innovation policy community at European level. One of its tasks is to demonstrate the significance and the added-value of socio-economic research at European level in the field of innovation research and innovation policy. The report is meant to be more than a summary of scientific findings of individual projects. It seeks to pull together and synthesize main findings from these projects clustered around a limited set of key issues, as a basis for extracting key implications for research and innovation policy. It must be noted that most of the findings are well diffused in the scientific community, but the translation from research into policy-making practice is lagging behind. Yet this translation is central for research, technology and innovation policy to be able to deliver adequate responses to the complex challenges ahead. The most recent insights and understandings of socio-economic research should be made accessible to policy-makers at European, but also on the national and regional level.

The projects reviewed tend to not discuss in detail the policy implications of their findings. All projects do contain relevant insights for research, innovation and technology policy, but with varying degrees of elaboration and concreteness. Some provide general frameworks and new perspectives to guide policy making but do not explicitly give concrete advice or more detailed implications. Others are very rich in empirical terms, but do not explore fully possible future directions of change. The purpose of this review is to attempt to extend the analysis of the policy implications of the results, beyond the scope of the projects themselves.

Although it is not the task of this review to carry out additional research work it aims to be original with respect to exploring policy implications, based on the theoretical and empirical advances made in the projects reviewed. The review is mainly based on the outputs published by the research projects, which have been analysed, structured and compared along a common

[1] All in all about 60 TSER-projects within FP 5 deal with socioeconomic aspects of technological change and innovation. For an overview of all projects and links for further details on the projects see also http://improving-ser.sti.jrc.it

[2] In the report, all projects will be referred to by way of acronyms. For an overview of project titles and acronyms see either Table 1 or the Annex.

pattern of analysis.[3] Many projects deal with overlapping topics, but mostly from a different theoretical perspective or based on different methodologies and empirical data. In view of the potential for synergies with respect to a policy-oriented analysis, a synthesis of the findings promises to deliver additional insights relevant for policy makers by comparing and discussing policy options and future policy challenges more comprehensively. In order to patch important gaps in the material available, the findings of other projects and from academic literature have been used occasionally to complement the findings where necessary and suitable.

Table 1: Overview of Socio-economic projects reviewed

Acronym	Title	Description
AITEG	Internationalisation, technology and employment in different geographical environments	The project studies the effects of globalisation on production, innovation and economic performance on the geographical, sectoral, and national level. The specific question is, which different forms of globalisation and technological change influence economic and employment growth, comparing European, American and Japanese.
CDIS	Comparative Dynamics of Innovation Systems	The project represents a collection of different subprojects addressing complementary research questions with respect to key hypotheses about National Innovation Systems (NIS) or Social Systems of Innovation and Production (SSIP). A new typology of SSIP is developed and used to answer these questions in a differentiated way.
CoCKEAS	Coordinating Competencies and Knowledge in the European Automobile System	CoCKEAS is a thematic network that aims to analyse the ongoing structural changes in the European Automobile System (EAS) along the entire value chain. Particular attention is paid to the relationships between the Original Equipment Manufacturers (OEM) and the First Tier Suppliers (FTS), but also the changes affecting lower tier suppliers, engineering companies, the distribution networks and the range of complementary services (e.g. finance) is taken into account.
Dynacom	Dynamic Capabilities Growth and Long-Term Competitiveness of European Firms: A Diagnosis and the Implications for EU Policies	Dynacom deals with the increasing importance of competences and capabilities for the corporate development and its implications for the competitiveness of Europe. The nature of the firm, the relationship between technological and organisational innovation, learning patterns, the vertical and horizontal boundaries of firms and the role of institutions are the research questions of the project.
ENGIME	Economic growth and innovation in multicultural environments	This thematic network aims to study the relation between cultural factors, cultural diversity, economic growth and innovation across and within European cities and thus delivers an interdisciplinary forum for the related research in Europe. The objective is to develop lessons for institutions and policies in culturally diversified cities.
ESSY	Sectoral Systems in Europe: Innovation, Competitiveness and Growth	This project aims to advance the understanding of sectoral innovation systems by analysing and comparing their key features, their differences and similarities, their dynamics and co-evolution. Moreover, their role for European growth and competitiveness shall be assessed. In scientific terms, it also aims to consolidate the approach of what is labelled as sectoral systems of innovation and production (SSIP).
FERP	The future of Europe's rural periphery, the	The project deals with two forces important for peripheral areas and its development: i) the impact of globalisation

[3] See the twenty short project reports prepared in the course of the review work. The report does not refer to each author and reference of individual contribution of the different research projects but refers mostly to the project as a whole using the acronym.

	role of Entrepreneurship in responding to employment and social marginalization	on rural peripheral regions, ii) the impact of entrepreneurship in peripheral areas. Moreover, the question of the role of the existing institutional, social and technological environment which facilitates entrepreneurship is investigated.
Flex.Com	Flexibility and Competitiveness: Labour Market Flexibility, Innovation and Organisational Performance	The research project studies the impact of labour flexibility on firm performance and innovation in different national settings. The positive and negative impacts of increased labour flexibility on performance contingent on long- and short performance, type of the firm, size of an economy and technological policy risk. The project debates also the question of the compatibility between the notion and trend towards labour market flexibility and the knowledge-based society.
HERN	Higher Education Reform Network: A collaborative partnership to explore, disseminate and advise on the university of tomorrow – in relation to societal change and lifelong learning needs and in the context of European enlargement	The higher education institutions are undergoing a reorganisation process in many European countries with the introduction of new funding principles, governance modes and increased autonomy. This thematic network with partners from 11 European countries explores new governance modes, teaching and learning modus, management change strategies and societal development that influence the reform of higher education in the context of the enlargement.
IEEF	Innovation and Employment in European Firms: Microeconometric Evidence	The project deals with one of the central questions of innovation economics and innovation policy, namely the relation between innovation and economic performance. The project tries to answer this question based on econometric modelling with various indicators of innovative behaviour on the one hand and economic performances such as productivity and employment growth on the other hand.
KNOW	Innovation-Related Knowledge Flows in European Industry: Extend, Mechanisms, Implications	The aim of the project is to study the extent, magnitude and type of innovation-related knowledge flows, within and between firms and other agents of European manufacturing and services industries. The project focuses explicitly on disembodied knowledge flows, e.g. by co-operations, communication tools or the movement of skilled personnel.
LEARNPARTNER	Learning in Partnership: Responding to the Restructuring on the European Steel and Metal Industry	The European steel industry has undergone a structural change for many years in its transformation from a low-tech industry to a knowledge-based industry. The project studies the linkages between restructuring, technological change and learning requirements for the personnel within the sector. The project develops and delivers theoretical and practical frameworks for partnership approaches between management and trade unions towards life long learning.
METDAC	Managing European Technology: Defence and Competitiveness Issues	METDAC is a thematic network that aims at consolidating the knowledge base on the institutional, organisational and policy level developed by firms and governments to deal with the new challenges for the defence technology sector raised by the conjunction of globalisation and the end of the Cold War.
POSTI	Policies for Sustainable Technological Innovation in the 21st Century: Lesson from Higher Education Science, Technology and Society	This thematic network aims to extract findings from recent research degree theses dealing with issues of sustainable technological innovation to get a better idea of emerging lines of thought in the research field. The project draws mainly on research work emanating from two traditions: Science, Technology and Society STS on the one hand and Science, Technology and Innovation STI on the other. Integrating approaches were also taken into account.

RISE	Research & Technology Organizations (RTOs) in the service economy – Knowledge infrastructures, innovation intermediaries and institutional change	The RISE project is dealing with the various types of RTOs and its innovation services for firms. The three main core questions of RISE are: 1. How to map systems of innovation? 2. How to balance the public and private activities in innovation systems? 3. How to steer systems of innovation? The study also addresses the difference to KIBS (knowledge intensive business service firms), which increasingly deliver knowledge-based services for industry.
SETI	Sustainable Growth and Employment Creation in the Technological Integration of the EU Economy	The project aims at analysing the interaction between new technology and economic growth in Europe. More specifically, it looks at the impact of three inter-related factors: i) the internationalisation of R&D and the impact it has on technological capabilities in the EU and the National Innovation Studies; ii) the development and diffusion of ICT, and here in particular the reasons behind Europe's poor performance in ICT adoption; and iii) the rise of business services on national patterns of specialisation and economic growth in Europe.
STAGE	Science, Technology and Governance in Europe	In recent years, different forms of public participation in decision-making about science and technology have been tested, for instance using concepts like consensus conferences (DK) or national consensus debates (NL). In order to realistically assess the role and potential of such initiatives, the project aims to develop a heuristic comparative typology of forms of public participation in decision-making about technology, innovation and science-bound issues.
TELL	Technological Knowledge and Localized Learning: What Perspective for a European policy?	The project studies the coordination and governance mechanisms for the emergence, diffusion and recombination of new technological knowledge. The project focuses on the technological, regional and organisational aspects of a successful application of technological knowledge by firms in different industries and regions. By understanding the governance mechanisms, which are important for the diffusion and accumulation of technological knowledge the project also aims contribute to policy issues, especially to the interaction of Technology, Industrial and Competition policy.
TENIA	The emergence of New Industrial Activities: Fusing Services and Manufacture	The research project studies the emergence and growth of hybrid sectors between manufacturing and service industries. The project focuses on three hybrid sectors: M commerce, multimedia, and business data communication. Thus, the project explores the structural change in the European industry with the aim to assemble indicators which allow to build an early warning system for developing hybrid sectors and to provide policy implications which create enabling conditions for such an emergence.
WEST-EAST-ID	Industrial Districts' Relocation Processes: Identifying Policies in the Perspective of the EU	WEST-EAST-ID pursues both theoretical and empirical objectives and aims to map a total of 43 Western and Eastern European industrial districts, out of which 15 are deepened by way of detailed case-studies. The research is driven by a set of research questions dealing with internationalisation and relocation processes, the development of industrial clusters, the role of local communities and institutional assets, and the policy needs which emerge from the industrial cluster perspective.

4 Overview of the main themes

In this report the topics addressed by the projects are clustered into five themes. These themes define broad areas that are perceived as central to innovation research as well as research, technology and innovation policy. The selection is not driven solely by research disciplines ('research themes') or solely by policy concerns ('policy issues'), but from a combination of both. Thus, the five themes provide an appropriate structure for the report. Individual issues are often relevant to more than one theme. Consciously the report avoids discussing the same issues under different themes to facilitate readability and simplify the presentation.

The discussion of the five themes emerging from the review concentrates i) on new empirical observations (such as the globalisation of knowledge production, or the enlargement process) that are relevant to current policy debates, or/and ii) on innovative theoretical frameworks and concepts (such as new systems approaches) that promise to deliver new rationales for research and innovation policy and governance. The themes are usually tackled by more than one research project, and most projects deal with more than one theme. Reference is made to the main projects drawn upon, which allows taking a systematic view on each theme and the challenges for research, technology and innovation policy it may raise[4].

The five themes are:

1. The impact of innovation: economic performance, employment and sustainability
2. The changing nature of knowledge production: organisational and spatial dimensions
3. The importance of institutions: between harmonisation and diversity
4. Human capital, labour market and innovation: the role of the individual; and
5. The governance of research, technology and innovation policy: rethinking the role and the processes of political decision-making

The impact of innovation: economic performance, employment and sustainability

The expectation of a positive impact of research, technology and innovation (and thus also of policy intervention in innovation processes) on key socio-economic performance indicators is the main motivation for dealing with these topics in a policy context. The ability to assess this impact is thus crucial for legitimating research, technology and innovation policy and for developing targeted policy measures. However, while at a general level the positive impact of innovation is hardly questioned, we still know comparatively little about the impact chains that link innovation with economic performance, employment and sustainability. In a first section, the impact of innovation on economic performance will be addressed, presenting empirical evidence and (econometric) modelling results at micro and macro level. Differences in the patterns of innovation and in the types of R&D investment are analysed with respect to their impact on various economic performance indicators using a range of data source (e.g. CIS, etc.). We will summarise findings of some projects that deliver empirical evidence on this subject like AITEG and Dynacom, whereas the projects IEEF and POSTI deal with this matter explicitly.

Employment and sustainability impacts are understood even less than impacts on economic performance. They are not investigated in much depth in the projects reviewed, either, but shall nevertheless be discussed briefly in two furthers sections. Both subjects have attracted

[4] Due to different and often specific research questions, different empirical data and methods the comparison and generalisation is not always possible.

much attention in public and policy debates in recent years. Establishing sustainable production and consumption systems is an economic opportunity and a societal requirement, but difficult to achieve due to the need for long-term organisational and institutional adjustments. The research projects POSTI and SETI deal explicitly with these matters; others simply touch upon them.

The changing nature of knowledge production: organisational and spatial dimensions

The increasing importance of knowledge, competencies and capabilities for innovation processes taking place within and between firms is widely recognised in academic and political debates in the last few years. Characteristics of the nature of knowledge such as tacitness, stickiness and local character – both in a geographical and in a thematic sense – are important for exploring future perspectives of a knowledge-driven economy. The changing characteristics of knowledge production exert a strong influence on how innovation processes need to be organised. Innovation has become a multi-facetted and complex process that requires combining various internal and external knowledge sources, and thus co-operation and networking with various partners. Knowledge production has been accelerated by the use of innovative ICTs ranging from the internet to new technologies used for gene sequencing. Moreover, the role of organisational settings and complementary assets for efficient knowledge production has grown in importance. This development is further enhanced by globalisation as the fourth main driver of change in knowledge production. While international co-operation in knowledge production and the key role played by ICT have clearly become key issues in policy, the implications of the local character of knowledge production and the pivotal role of "soft factors" are yet to be fully understood.

The projects AITEG, CDIS, CoCKeas, FERP, METDAC, Dynacom, KNOW, SETI, TELL and WEST-EAST-ID deal mainly with the nature of knowledge production and diffusion processes based on various empirical surveys and theoretical approaches.

The importance of institutions: between harmonisation and diversity

This theme focuses on the question of how innovation and technological change are influenced by institutions. Concepts of innovation systems and insights from the social shaping of technology play key roles in explaining the dynamics and performance of innovation processes and in informing the design of related institutions and policies. The extent to which, differences in institutional factors influence innovative behaviour and the output of firms and other actors, is a first subject addressed within this theme. Beyond the diversity of institutional settings for innovation in the narrow sense, other differentiating institutional factors in the wider context need to be taken into account as well, like for instance cultural environments, social values and cohesion, or the role of the state. These broader environments differ significantly across European countries. They represent on the one hand a barrier to the harmonisation of innovation systems and associated policies in Europe, and on the other hand they are a rich source of diversity. As a consequence, the general scope and the limitations of European research and innovation policies in the light of diverse institutional settings are addressed in a first section. The specific institutional possibilities and constraints at European level are tackled in a second section. The influence of patterns of interaction and networking between different actors on the innovation performance of regions and sectors also plays a central role in the projects discussed and is discussed in two further sections. Another subject of major importance is the transformation of industries and the emergence of new industries. For instance, the convergence of

manufacturing and services, or the rise of the ICT and service industries represents a major challenge for policy.

CDIS, COCKEAS, ESSY, Flex.Com, METDAC, RISE, TELL, TENIA, ENGIME and HERN deal with the topics mentioned and will by reviewed within this theme.

Human capital, labour market and innovation: the role of the individual

Well-educated and trained employees are an essential factor for developing and adopting new technologies as they can foster or hamper the introduction and diffusion of innovations. Entrepreneurial human capital is regarded as an important economic engine. Cultural, institutional and regional differences matter a lot in the dynamics of entrepreneurship across Europe. In the last decade the call for flexible labour markets has became so intense that the idea of life-long learning was increasingly seen as response of individuals to enhance employability and flexibility in work. The link between flexible labour markets and their possible impact on innovation performance, as addressed by some socio-economic research projects under FP4 and FP5. Related to this issue is the question of what types of skills will be needed in the future in order to respond to fast-changing demand.

Addressing these questions shows that general economic policy and labour policy are necessary complementary policy areas for an effective RTI-policy, a fact which calls for a further co-ordination between them. HERN, FERP, Flex.Com, and LEARNPARTNER deal with these issues. Their main findings and policy implications will be summarised within this cluster.

The governance of research, technology and innovation policy: rethinking the role and the processes of political decision-making

In this theme we will address specifically the question of the governance of research, technology and innovation policies. Policy-making is confronted with growing demands to solve major societal problems, and with a growing complexity of the issues to be addressed. This raises major challenges for political intervention in research and innovation. We will look at two important developments in this context. Firstly, different forms of public participation in decision-making about science and technology have been tested in recent years, but it is still unclear whether this development will lead to the emergence of a new paradigm in RTI policy making or whether the expectations are over-optimistic. Secondly, the need for coordination of RTI-policy with other, often sectoral, policies implies organisational and institutional changes to ensure the delivery of better coordinated policies and to enable processes of policy-learning.

Project STAGE deals with these issues explicitly, but they are touched upon also in a number of other projects like AITEG, CDIS, ENGIME, ESSY, RISE and WEST-EAST-ID.

5 Five fundamental themes for research, technology and innovation policy

5.1 The impact of innovation: economic performance, employment and sustainability

The ability to assess the impact of private and public R&D investment and innovation on economic performance, employment and sustainability, is crucial for research, technology and innovation policy in the light of the Lisbon and Gothenburg agendas of the EU. While there is general agreement that the impact of innovation is generally positive, our understanding of the complex impact chains that link innovation with economic performance, employment and sustainability is still rather limited. Yet this understanding is an essential pre-condition for designing policy interventions. Developing this understanding requires research both at the micro-level of firms and the macro-level of national economies. For instance, competitiveness is determined by a broad spectrum of factors, ranging from regulatory and policy frameworks, through expanding markets and competition to the ability to develop and deploy new products, technologies and services. Employment and sustainability impacts are even less well understood than impacts on economic performance.

Innovation and economic performance

Patterns of innovation and R&D investment, together with their impact on economic performance have been investigated in a range of projects, based on various data sources (e.g. the Community Innovation Survey - CIS) and applying different methods (econometric models, etc.). In particular the project IEEF puts the question of impact of innovation on productivity and employment at the centre-stage, based on econometric modelling using indicators of innovative behaviour and measures of economic performance such as productivity and employment growth.

The widely supported view that innovative firms have a better economic performance than non-innovative ones is confirmed by the results of several projects. For instance, analyses conducted in the context of the Dynacom project show that the firms which are systematic innovators earn above average profits, whereas occasional innovators earn, over time, below average profits. This pattern is persistent. The project found that new small firms in Europe are not able to become continuous innovators and do not survive as innovators for long. Those that survive are unable to widen their specialisation and move to emerging technological fields.

The link between R&D, innovation and productivity has been estimated by an econometric model (CDM model) in IEEF. According to the CDM model, investments in R&D determine the innovative output of a firm, which, in turn, has an impact on productivity. Based on data gathered by CIS 3, IEEF finds that R&D together with firm size, demand-pull and cost-push factors, explain the level and direction of innovative output (how much innovation and whether it is "product"- or "process innovation"). The size determines the propensity to perform R&D but not the R&D-intensity. Innovation outputs positively influence labour productivity. IEEF found **significant differences among countries** in terms of the innovative behaviour of firms, which are partly explained by differences in the industrial structures,

although other national factors seem to be important especially for differences in innovative behaviour of firms in high technology industries.
Beyond these general observations, the projects reveal the multitude of different relationships between innovation and economic performance highlighting that innovation is determined by a large number of factors such as sector, country, innovation type, type of firm, etc. Differences between process and product-innovations in terms of their impact on employment and competitive advantage at firm-level are investigated in several projects. Based on a longitudinal study in Spain, IEEF finds that **process innovations deliver only temporary advantage as firms have to introduce process innovations continuously in order to keep the required pace of productivity growth.** While important for productivity growth, competitive advantages founded on process innovation disappear quickly due to knowledge spill-overs.

Within this context AITEG researchers found that innovative firms that focus on product innovations tend to expand their market shares regardless of the dynamics of demand, whereas process innovators tend to expand production only in growing markets. This result is based on an analysis of innovation activities in the manufacturing and service industries, again partly based on CIS data. Moreover, the analysis shows that in high-tech industries the level of R&D expenditure is correlated with the rate of product innovation. In contrast, there is no clear relationship between the technological level of industries (i.e. high, medium and low tech) and their respective inclination to generate process innovation.

Innovation and employment

The relation between innovation activities, employment and wages is a central research question in IEEF. The main difficulty in providing a definitive answer to this question lies in the fact that both product and process innovations have both displacement and compensation effects, and these effects have to be assessed jointly. By estimating firm-level displacement and compensation effects in a model specifying a production function and demand for labour, IEEF shows that innovation displaces labour but also creates the necessary conditions at firm level to compensate for the displacement. Process innovations reduce marginal costs which, in turn, allows to reduce prices and thus expand demand with a positive employment effect. Product innovations allow a doubling of the expansion effect per unit of innovative expenditure. While positive potential net effects of process innovation tend to be reduced in the long run, when new competitors imitate the innovations, the positive potential net effects of product innovations tend to be persistent in the long run according to the study of Garcia et al. 2002). **The central conclusion of the work is that, on average, the net employment effects of innovation are estimated to be positive, even in the long-run.** Another IEEF study by Harrison et al. (2004) compares employment effects across France, Germany, Spain and the United Kingdom and shows that the **employment growth for innovators is consistently higher than for non-innovators** across the four countries. Overall, process innovations account only for small changes in employment in all countries, while product innovations tend to foster employment growth. Moreover, the patterns vary across the sectors, especially between manufacturing and services.

An analysis of CIS data within AITEG shows that the employment effects of innovation differ between sectors. **In R&D and knowledge-intensive sectors the employment effects of innovation are especially positive**. In addition, a CIS analysis reveals that **small and medium sized firms play a marginal role in the introduction of innovative products.** The empirical findings show that, in European industry, innovation strategies in the 1990s were focused on process innovations; an approach which often lead to negative effects on jobs.

AITEG pointed out that the sectoral structure of an economy affects to a great extent job creation and destruction, as individual manufacturing and service industries perform differently in relation to generating employment. ICT related jobs-growth is concentrated in a few countries, and in some service sectors the impact of ICT is mainly labour-saving. In the service sectors, AITEG found that innovation activities tend to substitute low skilled jobs with highly qualified jobs, and that in traditional and less innovative service sectors the net impact of innovation activities on employment is negative.

Innovation and sustainability

A surprising finding in the review is the almost complete absence of sustainability concerns from the projects. The only exception is the project POSTI that aims to map and structure emerging research on sustainable technological innovations. As an emerging field, research on sustainable technological innovations is characterised by a great deal of diversity and there is no dominant approach to the assessment of sustainability impacts of innovation.

The notion of sustainability is not homogeneously defined, but brings together quite distinct elements and perspectives. Most research work discussed in POSTI shares an emphasis on the environmental and the social dimensions of innovation as opposed to the economic dimension which dominates innovation research. Several examples of **environmental and socially acceptable innovations** are provided as evidence of the **benefits that these innovations can have at firm level**. These examples also show that when sustainable innovations are conceived as a combination of technological, ecological, economic and social considerations, knowledge becomes the crucial ingredient of success. This is where the findings from other lines of research about new modes of knowledge production, the role of intangibles, human capital and governance come into play. However, models and concepts are still sought as orientations and not the least also as a benchmark for assessing the potential impacts of innovation on sustainability. **The concept of "industrial ecology" is highlighted as one promising example, but also seen critically due to its focus on technological and organisational "fixes", rather than a balanced view of social and technological contributions to sustainability**.

The difficulties of finding adequate models and benchmarks for sustainable technological innovation reflect the systemic nature of the changes sought, which are very different from conventional product and process innovations. **The notion of system innovations is often used to capture the far-reaching character of the type of innovations that are required to move towards sustainability.** System innovations are seen as long-term transformations ("transitions") that require changes at the level of individual technological niches as well as at the level of the socio-technical regime that guides search processes, markets, user demand and policy. Transitions are also seen as continuous learning processes. Against this background, the evaluation of impacts of innovation turns into a stage within a long-term learning process.

Research on sustainable technological innovation rests upon the observation that market forces are blind when it comes to the relationship between innovation and the environment, which is why environmental policies and pro-active strategies are needed to promote social and technological innovations aiming at sustainability. However, only some rather limited policy areas are explicitly tackling environmental issues. Other policy areas, while being highly relevant for sustainability-oriented system changes, address the environmental dimension at best implicitly. In line with the transition philosophy, it is argued that a better integration or at least co-ordination of policies is needed. Such an integrated approach could

best be tested in particular areas/sectors like energy supply, building, urban development or transportation.

Main policy messages

1. Innovation is core to competitiveness, growth and employment. Innovation policy is a key economic policy.

2. The net employment effects of innovation are positive, especially of product- and service-innovations. Policy should facilitate in the first instance product innovations and focus on industries with high rates of product or service innovation such as KIBS or other knowledge-intensive sectors, in order to foster employment creation. There is a need to shift away from the emphasis on process innovations that characterised Europe's economy in the 1990ies.

3. The employment impact of ICT needs to be seen in context. ICT jobs growth is concentrated in a few countries only. While ICT innovation tends to lead to an upgrading of many service sectors, it has substitution effects in traditional and less innovative service sectors.

4. Overall the relationship between innovation and employment is determined by the interplay of many factors, several of which are specific to individual sectors or industries. For innovation policy measures to be effective with respect to employment they should be specific to individual sectors.

5. While being one of the key dimensions of European policy agendas, EU-funded research on innovation has yet to take the sustainability dimension seriously into account. This is a gap that should be filled.

5.2 The changing nature of knowledge production: organizational and spatial dimensions

The increasing importance of knowledge, competencies and capabilities for the development, innovative output and competitiveness of firms and the economy has been one the fundamental trends since the 1990ies. The changes brought by the knowledge-based society have dominated academic and political discussions in the last few years. Globalisation has been a driving force for technological development and innovation, possibly accentuating the importance of local effects and regional spill-overs for technological and economic development. Regions, clusters and cities have become attractors of technological innovation.

The consequences for innovation and research have been manifold. The diffusion of new digital technologies and networking opportunities across the globe allows transferring more information between various agents much faster than before. Knowledge flows between different kinds of actors across the economy are a central pillar for innovation performance. Empirical findings show that the amount of national and international information and knowledge exchange and networking has increased considerably. ICT enables networking and interaction between different agents of innovation systems and allows reducing the costs of knowledge diffusion. Moreover, innovation without R&D has become important, for instance in the service sectors.

Innovation as a process integrating internal and external knowledge sources

Understanding the nature and dynamics of knowledge production in firms has been a major topic within the scientific literature. The Dynacom research project, whose members are at the forefront in developing firm theories, sees the innovating firm as a combination of technological, organisational and complementary competencies. Technological competences include the skills of individual members of an organisation, and organisation-embodied elements such as scientific and technological information and knowledge and organisational routines aimed to design and produce products and services. Organisational competencies are the bundles of knowledge and routines that are required to govern the coordination and social interactions inside the organization as well as with external actors such as customers and suppliers. Dynacom stresses that technological innovations often require at the same time the introduction of organisational innovations, which, in turn require specific organisational competencies.

Dynacom sees some weaknesses in Europe in relation to organisational competencies. In Europe, organisational innovations tend to be piecemeal adjustments by nature and have relatively low diffusion in comparison to the US. According to Dynacom, more institutionally structured labour relations as present in many central/northern European countries can be conducive for the diffusion of new organisational practices (cf. Coriat/Weinstein 2002). Within this context Dynacom studies show also that, for instance, Japanese firms are quite successful in adopting their work practices to different national human resource systems.

For Dynacom researchers the accumulation of competencies and the **interplay between organisational and technological competencies, lead firms consistently down a path of diversification**. Dynacom contradicts the common belief that there is a "return to the core" or a "refocusing and specialisation" in industry. European firms, like US and Japanese ones, show increasing business diversification in many industries, such as office equipment, aircraft, chemicals and mechanical engineering. In general, US firms are more diversified than European and Japanese firms, except in pharmaceuticals and chemicals. Diversification was a common phenomenon amongst all firms in all product groups in Europe, the US and Japan in the 1990s. In many areas large firms became more diversified in their technological competencies in the 1990s.

The effort to grow fast through diversification challenges classical in-house R&D management practices. Firms need to balance the exploration of new fields and the exploitation of the results of former explorations continuously and efficiently. This careful balancing act is probably partly responsible for the **increasing importance that firms attribute to accessing and using external knowledge**. Amongst different ways to access external knowledge, R&D cooperation seems a particularly important way for firms to complement internal competence-building. The KNOW project deals explicitly with the topic of knowledge flows in the innovation process.

In line with findings from other empirical innovation surveys, KNOW confirms that the customers are the most important external source of information for innovation, followed by suppliers and competitors. Traditional occasions such as fairs, exhibitions, conferences, etc. are still very important means of being kept informed. Scientific and technical information is the dominant type of information gained from external sources, followed by information relevant for product launch. Innovative companies co-operate more often with suppliers and customers on vertical relationships, larger firms co-operate more frequently with universities and public research institutions. According to responses to KNOW, public research

institutions are regarded as important sources of innovation by the very largest European firms[5]. KNOW depicts also some differences between countries: Dutch firms seem to be more open to external sources, whereas firms from Germany and Britain value internal knowledge as more relevant. In general, national sources are more important than international channels.

In all five sectors examined by the KNOW survey[6], about two thirds of the innovations were developed in-house, about 10% were bought in and about 20% were developed in co-operation. Interestingly, the innovations developed in-house often had a positive significant link with the share of innovation in the total sales of the firm, which was not detected in the innovations set up in co-operation. This result contributes a new perspective to the difference in strategic importance between in-house R&D projects and collaborative R&D ventures.

Firms are frequently active in **innovation and research networks,** and research networks have been established by the European Framework Programmes. KNOW studied research networks initiated between 1992 and 1996 within the European Framework Programmes. These networks are characterised by a few central agents with many ties and a larger number of agents with a few ties which are placed in more peripheral positions in the networks. A relatively small number of firms, universities and research institutes have emerged as core players in European research networks. KNOW found no clear relationship between the position within the network and the extent of innovation activity.
The KNOW team argued that in **early stages of technological development**, policy should attempt to create **networks of excellence and to open up existing networks to potential innovators.** In **mature industries and networks,** policy should aim to **link peripheral actors to external networks** in order to foster a **broad diffusion of knowledge** and break down barriers to entry. The more important networks become, the more policies should foster absorptive capacities.

This is consistent with the observation of TELL that **during the growth of an industry the nature of the knowledge systems changes**. In initial phases of the development of industries, knowledge is often local, in mature phases the production and use of new knowledge tends to be more global. According to TELL, different industries are characterised by different **knowledge regimes**, co-ordination and governance mechanisms and thus respond differently to different policy measures. TELL studied five industries (clothing, telecommunication, automotive, life sciences, aeronautics) with different knowledge characteristics and knowledge-organization, partly influenced by public activities. In the clothing industry important organisational interfaces are provided by knowledge-intensive business service firms (KIBS) and Innovations Relay Centers. The automotive industry, in contrast, is characterised by complex and codified knowledge production and diffusion processes. In this industry the emergence of innovation networks between different players is crucial, as well as the development of market arrangements, e.g. through markets for patents. The aero-engines industry is characterised by a huge demand for coordination between highly specialised firms. The coordinators, mostly large companies which sell the engines, define modular architectures for the engine and span their technological capabilities over a large number of fields.

The changing nature of knowledge production and knowledge systems raises the issue of the role of Research and Technology Organisations (RTOs) in the development of industries. In general, both **RTOs and KIBS act as knowledge brokers and "bridge builders" between scientific knowledge and industrial application**. Project RISE looked at these organisations

[5] This contradicts the findings of the Community Innovation Survey (rounds 1 and 2)
[6] Based on data of 558 innovative firms in five industries in seven countries.

which especially serve as intermediaries and knowledge-transfer agents between the rather formalised explicit knowledge of public institutions and the often tacit knowledge bases of private firms. RTOs provide specific services for translating science and ideas into new products and help firms launch innovations in markets. They are a heterogeneous group highly influenced by their regional and national contexts. RISE defined different roles and services performed by RTOs which were then analysed via seven cluster studies: automotive components in Germany, telecommunications in Italy, book printing and publishing in the UK, multimedia in the Netherlands, food processing in Norway, and biotechnology in Sweden and Portugal.

The most important public roles of RTOs are to correct market failures, to diffuse technology, to conduct R&D and contribute to published scientific research, and to train a pool of qualified scientists and engineers. Three functions most frequently performed by RTOs in the clusters were publishing, linking with universities, and R&D. In general, the more governmental funding RTOs receive, the more basic research they are carrying out. Although RTOs in most countries, except the UK, tend to concentrate on 'upstream' activities in the innovation chains, some have extended their activities into 'traded' services, e.g. supplying and implementing software, workflow restructuring, prototyping etc. RTOs and KIBS deliver similar functions and provide similar services, but to different markets. It is not possible to identify a clear division of labour between RTOs and KIBS according to the different functions they offer. However, KIBS are more often engaged in market-near ('downstream) areas. RISE found that the competence level of firms limits the ability to consume services by RTOs and thus collaborative arrangements are often required.

RISE argues that policy should adopt a service economy perspective, rather than a perspective based on R&D for manufacturing. Policy should facilitate and fund collaborative R&D in supply chains, since system and market failures occur in many clusters. Based on cluster analysis, customised innovation programmes can be developed by policy.

The local dimensions of knowledge production

Learning, **knowledge creation and innovation are inherently local and cumulative by nature**. Technological spill-overs and knowledge flows are to a certain extent geographically localized. The increased knowledge specialisation, the increased complexity of products and the need for various knowledge bases and functions has complicated the nature of the innovation process and the role of localised effects. TELL research shows that the **'local' and 'global' dimensions of knowledge production** are highly interdependent. In general, local effects are often related to functional specialisation, although also industry regulation and standards setting activities can have localising geographic effects. Complex technologies are often hierarchically structured and governed by large global enterprises, as for instance, in the case of aeronautics where delocalisation is more evident and R&D is performed in co-operation between large, globalised groups. TELL shows that the telecommunications sector needs both, localised learning and learning within large integrated international firms. Large telecommunication firms set the rules in terms of standards and architectural knowledge, and small firms can exploit local advantages. The design of modular technologies and complex products is generally an important strategy by large firms and allows exploiting economies of scale and scope.

ENGIME studies the economic development of large multicultural cities and addresses the question of how cities with diverse industries perform in contrast to cities with one dominant industry. The extent of spill-overs within and between industries lies at the heart of this

question[7]. The synthesis of the empirical evidence carried out by TELL about the role of different types of spill-overs is inconclusive. Both, diversified and specialised cities are vital for innovation and diffusion processes in the economy. There is some evidence, that diversified cities are more important for product innovations, whereas for process innovations specialised cities fulfil an important role. Knowledge spill-overs are usually stronger in cities than in rural regions. To the extent that diversity positively affects knowledge spill-overs, diversity can foster innovation and economic growth.

The local character of knowledge production has consequences for the governance and coordination of innovation policy. Antonelli (2003, 6) points out the challenges of modern innovation policy with respect to its localised character when he states: *"On the one hand efficiency and self-selection processes favour the concentration of innovation capabilities and innovation subsidies in a few core regions. On the other hand, innovation is most necessary for peripheral regions, yet deprived of innovation capabilities and unable to attract European subsidies"*. Polices have thus to exploit the opportunities from technological districts but at the same time to foster economic development in peripheral regions. Antonelli pleads thus for including an assessment of the regional location of partners and the potential of spill-over effects in the region as selection criteria when evaluating proposals for research networks or programmes. Obviously, the quality and capabilities of the local research base play an crucial role for these allocation decisions.

Antonelli also calls for a **stronger use of the innovation potential of universities** as knowledge and spill-over generators in peripheral regions. Specific innovation programs should exploit the innovation potential of universities, especially by strengthening their localized spill-overs to SMEs or young entrepreneurs. Here relevant lessons are drawn by EAST-WEST-ID, in relation to the re-location of firms from West European countries to Central and East European countries, and especially in relation to industrial cluster initiatives. Local conditions matter and a "one-size-fits-all" approach to policy do not work.

The internationalisation of R&D, mainly advanced by multinational corporations (MNC), is driven by many factors, but the ability to absorb and acquire technological spill-overs from local knowledge or specific firms is central. The need to respond to demand and market conditions in different countries is an important trigger for the internationalisation of R&D. Apart from market-based arguments, supply factors, such as skilled labour, and the local knowledge base and public infrastructure, are increasingly central for carrying out R&D abroad. Dynacom research shows that learning in MNC is strongly influenced by the local environment of affiliates. MNC access a region's local skills and expertise and enhance them. MNC are able to source technologies in specialised regions, to create cross-border networks and to diversify their technology base. This, in turn, deepens the technological profile of regions. Dynacom research shows that Japanese business practices are transferred within Japanese MNC, but that the local context affects the way affiliates operate Japanese subsidiaries abroad never look like their parent companies.

MNC try to locate their subsidiaries in regions where the knowledge spill-over effect is expected to be high. However, foreign subsidiaries can also represent inflow of technological knowledge to the home country, often labelled as "reverse technology transfer". Dynacom and AITEG argue that the trend of many European firms to carry out R&D outside Europe,

[7] There are two opposite views about the role of specialisation and diversity. Whereas Marshall, Romer and Porter state that the concentration of an industry in a city fosters knowledge spill-overs between firms. In contrast, Jacobs believes that the most important knowledge transfer come from outside the core industry. Thus, it is the variety and diversity of industries within a city or regions that facilitates innovation and growth.

especially in the US (despite the efforts of the EC for research and technological development), harmed innovation systems in Europe. AITEG research shows that the internationalisation of R&D may also accelerate the inflow of new technology from other countries, particularly, if they are at the technological frontier. Based on a patent citation analysis of US and European MNCs they show that companies from both regions use their foreign-based R&D activities to exploit the knowledge base of the other (host) region. However, **European MNCs compared to US MNCs are less able to exploit the knowledge acquired abroad in their home countries**. Thus, reverse technology transfer seems to be stronger for US MNCs. Only in the computer sector European MNCs seem to perform better in reverse technology transfer.

R&D investments abroad do not necessarily substitute for R&D investments at home or erode the home country's technological advantages, as commonly believed. AITEG analysis indicates that the internationalisation of R&D by firms might accelerate the inflow of new technology from countries at the technological frontier since even technologically advanced countries cannot provide strong innovation systems to all their industries and technological fields. Empirical investigations show that domestic firms equipped with high technical skills are better prepared to take advantage of complex evolving technologies developed by MNC. A main policy conclusion is that innovation policy has to exploit these potential internalisation aspects of other countries' innovation systems. National policies should strategically focus on certain fields and support their companies to exploit their international spill-over potentials, inward and outward, instead of only focus on attracting as much inward investments as possible, as AITEG concludes.

The strategy of MNCs to diversify R&D and production within and outside Europe gives them not only advantages in terms of risk-spreading but also a stronger bargaining position on labour markets and towards governments. An important policy conclusion from AITEG is that governments should pursue **strategies that enhance the power of the countervailing partners such as labour, consumers and SMEs**. These parties are often able to organise themselves and operate across nation-states. A lack of coordination between the technological, organisational, institutional and social innovations might harm the development and diffusion of new technologies. Therefore, according to AITEG, attention has to be paid to the social arrangements in particular concerning the role of learning.

Main policy messages:

1. European firms lag behind competitors in organisational innovations and capabilities which are essential for exploiting new technologies. The development of organisational innovations is institutionally embedded, e.g. by workforce training, industrial relations etc. This needs policy attention even though there is no evident "one best way" to enable the necessary changes in Europe.

2. RTI investments outside Europe, such as in China, are not necessarily a substitute for R&D in Europe. A strong European R&D is an essential complement for the increasingly stronger R&D in other parts of the world. Europe must ensure that the conditions are conducive for internalising international spill-overs and for competing on global markets.

3. Networking is often seen as key to exploiting Europe's diversity while building-up critical mass. Approaches to network-building differ across industries. In early phases of technology development, policy should aim to create networks of excellence of a limited size, built around a stable core and open to innovative inputs from outsiders. In mature industries and

clusters, policy should aim to link peripheral actors to external networks, in order to foster a broad diffusion of knowledge and break down barriers to entry. The more important networks become, the more policies should foster absorptive capabilities in firms.

4. RTOs, often public, tend to perform overlapping services with private KIBS firms, although they may still differ with respect to the closeness and time to the market. RTOs could perform a significant public policy function by providing a link between excellence-based networks to diffusion-oriented networks. For this to happen, they would have to become "network organisers" with a strong orientation towards both manufacturing and services.

5. RTI policy in Europe, to the extent that it subsidizes industrial R&D, would benefit from incorporating criteria related to the regional development and potential spill-over effects, and from strategically focussing its international cooperation strategies on particular sectors. The knowledge characteristics of the industry and the development stage of specific technologies have to be considered.

6. Local benefits from strong local partnerships between governments, research and educational institutions, labour, consumers, SMEs that can involve MNCs in processes of appropriating spill-overs from international R&D should be more strongly considered. Such policies would also encourage a demand pull oriented RTI policy and would allow "empowerment of employees and users".

5.3 The importance of institutions: between harmonisation and diversity

The determinants of the behaviour of economic agents have been discussed in social sciences and economics for decades, with behaviourists proclaim the ability of deliberate choice and discretion of action, and institutionalists stressing the importance of the institutional environments and framework conditions for decision making. It is now generally accepted that institutions frame behaviour even if they do not determine it.

This analysis prevails in the case of the 'European paradox' i.e. Europe's perceived failure to capitalise in the market-place on its comparatively strong position in science and technology. According to the Dynacom project, Europe has its strongest publication performance in established disciplines such as chemistry and physics while the US is stronger in younger fields such as molecular biology, biomedical engineering and informatics.[8] Dynacom stresses that the R&D performance of the EU-15 has been declining in the 1990s in comparison to the US, despite variations in sectors and countries. For instance, in the area of mobile communications and in some Northern European countries, competitiveness has been be strengthened. The explanations for this are sought for in the institutional and framework conditions for conducting research and innovation activities in Europe, such as, for instance, insufficient incentives and motivation at universities for turning research into applications, a lack of cooperation between science and industry, and administrative, legal and formal rigidities in research organisations and programmes. In spite of some important changes in the past few years, the US are still perceived as a more attractive environment for conducting research than Europe, both for individual researchers and for research-intensive firms. As a

[8] This development has been supported by large public R&D funding in the US according to Dynacom.

consequence, about one third of European-based large firms' R&D is carried out outside their home country, of which about 20% in the US and only 14% in other European countries.

The institutional factors determining the attractiveness of different locations for conducting research – either as an individual or as a company – can be of various kinds. **Institutions can be interpreted as 'rules of the game'** influencing and shaping emergent patterns of behaviour, either as externally imposed and enforced rules or as emerging rules within a community. They can also be **interpreted as the possibilities to access to limited resources** for conducting certain types of research activities.[9] This understanding of institutions is reflected in the innovation systems approach in its different variants, which has come to dominate innovation research since the mid-1990s. Innovation systems (IS) can be defined to include all important factors that influence the development, diffusion and use of innovations, as well as the relations between these factors. The IS approach assigns to institutional factors a central role in shaping innovation, behaviour and the output of firms and other agents, and stresses the need for coherence within and between institutions. Innovation is seen as resulting from the interaction, learning and knowledge-transfer processes, between many actors under the influence of a coherent institutional framework. Within the literature different definitions and concepts of innovation systems have been proposed. **The initial emphasis on National Innovation Systems (NIS) has given way to regional and sectoral approaches** as a reflection of the need for greater differentiation and heterogeneity. National, regional and sectoral systems are highly interdependent: sectoral specialisations contribute to the shaping of regional and national innovation systems, while the institutional settings can orientate the sectoral specialisations. Hence, similar sectors have different features in different countries or regions.

The projects AITEG, CDIS, FERP, Dynacom and TELL confirm in general that differences of technological growth and specialisation patterns are dependent upon the institutional setting, and that these are highly location-specific. Regional and sectoral institutionally embeddedness will be addressed subsequently.

Institutional aspects of regional differentiation

The emergence of different regional innovation systems across Europe is driven by locations strategies of large firms, agglomeration effects as well as social and political developments. Overall, European systems of innovation at national and regional levels are remarkably diverse. For instance, Germany, Italy and France include highly innovative and technologically backward regions. The UK, Sweden and Belgium seem to be more homogeneous. AITEG delivers evidence for this pattern based on an analysis of patenting activities across Europe. Based on an analysis of technological activities measured by patents AITEG shows that the technological activities of large firm are highly concentrated across Europe and there seems to be no convergence process happens, at least not during the 1990s.[10] Thus, they conclude that the concept of NIS which is often understood as homogenous socio-economic entity is not feasible: NIS consists very often of heterogeneous Regional Innovation Systems.

Apart from globalisation of research and innovation and its impact on attracting mainly large companies entrepreneurial start-up activities are influenced strongly by the regional institutional environment. FERP, which studies the role of entrepreneurship in peripheral

[9] See for instance Coriat and Weinstein (2002).
[10] However, as the study of the 69 European regions shows, the geographical dispersion of R&D of MNC is only weakly associated with the levels of economic wealth.

European regions, delivers evidence that the impact of national and regional characteristics is even stronger than industry-specific factors in these regions. For instance, **the difference in business performance is more significant between countries than between different regions within a country**. This is another confirmation for the strong influence of the institutional setting shaping economic behaviour.

While entrepreneurial activities are strongly influenced by the regional environment in general, according to AITEG the innovation behaviour of established firms is more influenced by the sector they belong to than the country. AITEG research based on CIS data shows, for instance, that some innovation dimensions such as co-operation behaviour are the result of specificities of national innovation systems, while other innovation dimension, such as the importance of product innovations versus process innovations, are common features of sectors and industries across countries.

TELL is especially interested in the regional and local context of the knowledge production. Localised knowledge is generated within a system characterised by different governance mechanisms such as the IPR regimes, specialised intermediaries and by networks. Such "knowledge systems" need to be analysed in order to identify specific shortcomings which can then be improved by policy measures. An aim of innovation policy measures in general is the reduction of cost of information for finding out where relevant knowledge is located and the support of coordinating the production and use of this knowledge. The case of the Scottish mobile industry studied by TELL shows that a publicly led set up of an alliance of telecommunication firms resulted in an ease transfer of information. Building up local interfaces (e.g. infrastructure, targeted R&D user-oriented projects, local associations, etc.) was also relevant for the development of the ICT industry in Sophia-Antipolis, which is successful despite the global shakeout since the 1990s.

The main conclusion for policy is that the efficiency of 'knowledge governance' is a major innovation policy concern. Moreover, according to TELL, innovation and regional policy have to deal with the trade off between two goals: the exploitation of opportunities from technological districts and localised increasing returns, and the fostering of economic development in peripheral regions. The TELL consortium thus calls for including an assessment of the regional location of partners and the potential of spill-over effects in the region as selection criteria when evaluating proposals for research networks or programmes.

Another view of institutional factors influencing innovative behaviour comes from looking at the specific environment of large cities. ENGIME sees important factors for innovation not only in the industrial diversity of a city, but also commercial and other types of diversity such as cultural and ethnic diversity. ENGIME indicates that **cultural characteristics** are crucial for creating an environment conducive to innovation and stimulating communication between individuals is an enabling condition. However, cultural diversity may also lead to cultural shocks and conflicts which have costs for the economy. In highly diverse environments conflicts may have positive effects on innovation, but this requires proper communication. Conflicts might then lead to a higher variety of ideas, products, rules and innovations. The ENGIME researchers deliver some empirical evidence that there is some kind of optimal conflict level (not too low or too high) which creates the most innovative outcome. As ENGIME points out, there is some evidence that "good diversity" exists, but the research could not define it more precisely at the current stage. The ENGIME consortium concludes that diversity can have a positive impact on growth and innovation. The next step is to identify **under which conditions the advantages of diversity can best be exploited while minimising the negative consequences.**

Sectoral innovation systems

Sector-specific conditions strongly influence the nature and dynamics of the innovation processes within and between different actors. Several large research projects have conducted detailed case-studies of the innovation dynamics in different sectors, and many of them such as CoCKEAS, ESSY, METDAC, and SETI use explicitly the concept of sectoral innovation systems. **As ESSY argued there is a clear need for a more differentiated analysis of innovation systems as just looking at geographically delimited entities. The specificities of sectors are rooted in the knowledge, in the actors, their interactions, as well as in the institutions guiding the behaviour of these actors.** The projects confirm the strong impact of sectoral factors for the development of industries such as pharmaceuticals, telecommunication or transport. Major differences exist across sectors which, in turn, greatly affect the determinants of countries' or world regions' international performance at the same time. In general, these projects deal with structural change and the question of Europe's dynamic in "old" and "new sectors" as well as the emergence of new sectors between manufacturing and services (fusion), which will be described subsequently.

ESSY studied six sectors: Chemicals, Pharmaceuticals and biotechnology, Software, Telecommunication, Machine Tools, and three sub-sectors in services (Airport, Remedy to Cateracts, Retailing) in order to identify sector- and country-specific factors explaining industrial leadership in each sector. The main factors affecting industrial leadership vary a lot in the six sectors. In pharmaceuticals and biotechnology, for instance, a strong science base, a tradition in the university-industry relationships and transfer, a domestic market and a clear legal framework (IPR) frame innovation and competitive success. The project illustrates that the UK, even having some favourable conditions in the beginning of the biotechnology area, failed to be successful in the long run (as compared to the US) and shows the role played by the lack of technology transfer offices in universities. The machine tool industry is characterised by tight user-supplier interactions, strong integration of manufacturing and design capabilities and a necessity to upgrade labour and engineering skills continuously. Here, some European countries such as Germany were able to stay competitive in the 1980s and 1990s against US and Japanese competitors by specialising in niches. In the telecommunications industry standards and regulation play a critical role. The GSM standards helped Europe's telecommunications equipment industry to achieve world leadership which was also a result of a concerted effort between European Telegraph and Communication Authorities, public regulation and some innovative firms.

The specificities of processes of structural re-organisation in individual sectors and the diversity of institutional determinants that shape their transformation can be illustrated by the two projects CoCKEAS (automotive, see Box 1) and METDAC (defence, see Box 2). In both cases we can observe a shift in the "centres of gravity" of the sectors. In the automotive sector, the first-tier suppliers have been gaining influence as major design, development and integration functions for the main systems have been delegated to them by the original equipment manufacturers (OEMs). In the defence industries, the prime contractors continue to concentrate on military applications, but draw on a more diversified range of suppliers that combine and integrate military and civil technology.

The re-organisation of the automotive industry

In the automotive industry, the reorganisation process goes hand in hand with a process of rationalisation and improved coordination between all the different firms along the production chain, from vehicle design to retail distribution and services. It is driven by technological developments, especially in ICTs, by an increasingly competitive process of internationalisation and regionalisation, and by changes in the institutional context, most notably with respect to the growing influence of shareholders and institutional investors on corporate strategies. This entire set of developments has significant consequences for both upstream SMEs and downstream sales and services. Lower-tier SMEs had difficulties to keep pace with the rising requirements from OEMs and FTS, in terms of quality, price, product range, cooperation and information exchange, quality control, etc. With general service supply companies increasingly turning into severe competitors to OEM's own sales and services, it is increasingly difficult for OEMs to ensure that customised services to final users remain their main source of profits.

Both example sectors investigated in CoCKEAS and METDAC confirm the distinctiveness of European systems vis à vis the US. The European automobile system is characterised as "co-evolutionary" where OEMs and FTS co-operate closely with each other and where co-design and co-development characterise the relationships with other key players. The European Defence Sectoral Innovation System is about to find a new balance between civilian and military applications, as well as between global market presence and national interests.

Back to business: The re-formation of the defence industry

The defence technology industry is a very specific case from an innovation perspective, in which the classical understandings of innovation processes do not apply and where there are particularly strong intertwined relationships and vested interests between policy and industry networks. The "national interest" argument, international competition, new strategic approaches in defence and security policy and the dual use debate have delayed the integration process in Europe, in contrast to other industries. However, a fast process of internationalisation (and somewhat slower of globalisation!) can be observed, with trans-atlantic innovation and production networks emerging. Whereas the prime contractors have concentrated on their military branches since the industrial shake-out in the 90s, military-civil integration seems to have become a common phenomenon at the level of suppliers (although this trend has been put into question since the 2001 events). As outsourcing has become an important strategy in the defence industry, one can argue that the knowledge base has been broadened and comprises both military and civil components. Also with respect to the financial constraints and requirements, the defence industry has become more "normal" and is obliged to meet tighter economic targets to satisfy stock markets; a development that tends to limit the influence of national governments.

The sectoral studies in the above mentioned projects show that each sectoral system has its specific features, structures, dynamics and drivers for industrial leadership. The ESSY research team concludes that European firms tend to perform less well in "new sectors" where emerging disciplines offer opportunities for new product and service development such as biotechnology or the internet. These are characterised by a complementarity between a strong IPR regime, an efficient external market and corporate systems dominated by outsiders (e.g. financial investors). These types of institutional settings are conducive for exploiting new scientific discoveries where especially patents are important for attracting financial resources. European firms do not have a general weakness in science-based sectors per se. They rather suffer from a lack of knowledge and capabilities for the commercial exploitation of

knowledge and discoveries in new disciplines. European firms tend to be stronger in sectoral systems where the internal markets are relatively more important and corporate governance systems are dominated by insiders. In this case, technological development is more "open" which allows capturing at low (or zero) costs the benefits from discoveries by new innovators which enter the market where appropriability and protection is mainly based on specific capabilities and internal learning. Such a model does not require strong capital markets. Here, products often derive from established disciplines such as chemicals or aeronautics where user-supplier interactions are important. This situation is found in the automotive sector, in machine tools, and in some segments of software, characterised by scale intensity and/or specialised suppliers. Within these sectors product innovation regularly requires the close interaction of a number of different partners and competencies along the value chain, and in this the congruence between organisational behaviour and institutions observed in Europe, is strength.

A special form of structural change is related to the emergence and growth of **hybrid sectors between manufacturing and service industries** which is addressed by TENIA. The project focuses on three hybrid sectors: mobile commerce, multimedia, and business data communication. Hybrid sectors are the result of a process of fusion whereby converging technologies become part of a common technological paradigm. The fusion process creates new sectors at the interface of manufacturing and services and drives the transformation of existing activities into hybrid activities, which span across different technological fields and different industries.. The notion of hybridisation means to identify a platform (e.g. a set of standards, or a set of value chain relationships) that emerge from integrating technologies which traditionally belong to different sectors. TENIA highlights some cross-cutting issues which are of relevance for structural change in general: networking, asymmetric power relations, technological standards, public procurement, regulation and technological bottlenecks are issues to be treated by policy in emerging hybrid fields. Business services tend to play an increasingly role at the interface between manufacturing and services. As stressed by SETI, "virtuous circles" of growth can be created due to the interaction between the use of (both domestic and foreign) business services and technology accumulation in firms (e.g. with respect to innovation and uptake of ICT).

The role of institutions between harmonisation and diversity

The last two subchapters illustrated the heterogeneity and diversity of the regional and sectoral level innovation systems. We now turn to the question to which extent variety harms innovation. Various institutions such as the research infrastructure, education system, industrial relations, IPR system, tax incentives, corporate governance, etc. influence that innovation behaviour of various actors on regional and sectoral level as well as at national (and in some cases European) level. Institutional arrangements in Europe are characterised by a great deal of diversity despite the fifty years of European integration and a continuous trend towards globalisation. Europe is becoming even more diverse with the integration of the New Member States.

In general, the institutional differences across Europe tend to be the result of historically grown process rather than the result of a systematically planned activity. On the whole, one cannot observe an overall convergence between the different institutions, even if the EU-countries have a few trends in common such as the move towards a knowledge society. According to CDIS European countries tend to diverge in terms of social protection, labour regulation and income distribution. Different institutional configurations co-exist successfully. CDIS call for a revision of the hypothesis that there is a convergence towards a

unique technological and institutional model; at least a more differentiated perspective on that issue should be adopted.

A key question is, hence, to which extent institutions should be harmonised on the European level. This is a crucial issue due to the trade-offs associate with highly diversified or strongly harmonised systems. The critical issue is how much diversity we need and in which respect harmonisation of institutions is called for. There are several advantages in harmonisation. These include reduction of transaction costs, possibility to build critical masses, large unified markets, and unrestricted mobility on the labour markets. At the same time diversity and differences within Europe are crucial factors fostering variety and thus innovation.[11] The diversity of institutional frameworks provides a wide range of 'testbeds' for innovation that are specifically geared towards the historically grown conditions in a region or a sector. Institutional diversity can thus be a source of value (Touffut 2003) and strength insofar as it helps foster the economic dynamism of a region and the quality and innovation of researchers and research organisations.

As highlighted in Dynacom, Europe has **distinctive institutional arrangements which allow supporting a wide range of organizational capabilities**. Germany, for instance, has its strength in a cumulative pattern of innovation which rests upon intensive intra-organizational learning and the highly skilled workforce. The US in contrast, has its strengths in science-based disruptive innovations. Hence, the general lesson of the Dynacom research is that one cannot identify "one best way" of organisational competence development and learning. Dynacom stresses the importance of a few European institutions, such as the training system or patterns of labour relations which strongly influence the ability for firms to implement the necessary organisational adaptations. Dominant organisational arrangements influence the matching between sector-specific combinations of corporate competences, organisational structures and strategic orientations and the institutions in with a firm operate. Though, **Europe should not adapt blindly the 'US model' but it should strengthen the specific institutional advantages it has**. An example mentioned by ESSY is the Japanese "Just-in-Time" concept introduced in the 1980es which helped the car makers to catch up by a series of organisational innovations which became a "dominant architectural design" for the sector as a whole. ESSY concluded that *"… these companies were able to "catch up" because they were able to innovate and to follow their own paths towards the state of the art in the sector"*.

The ability to bridge **between the dynamics of innovative opportunities and its economic exploitation is regarded as a pre-condition to overcome the 'European paradox'.** The institutions and organisational arrangements to facilitate this bridging function are generally perceived as being in need of improvement, and a lot has been done in this respect over the past ten years. Dynacom recommends to strengthen the science and technology system to generate a strong pool of knowledge and innovation opportunities, and to improve institutions and organisational arrangements to bridge the dynamics of innovative opportunities with their exploitation by business firms. In addition, Dynacom suggests to **enhance long-term research focused on scientific quality criteria, funded by the European Union.** High quality academic research should become a principal objective of EU policies. The EU funding should complement and compete with national research funding and not substitute them. Clearly, the goal to establish the European Research Area can be regarded as measure to cope with this challenge.

[11] As Hofstede (1991) states, the EU can be thought of as the biggest laboratory of intercultural collaboration of today's world. Thus, as ENGIME shows, cultural diversity has an impact on economic growth, entrepreneurial activities and innovation.

To conclude, there are some promising "combinations" of scientific, technological and organisational arrangements conducive to competitiveness. At the same time, institutions and polices provide some "combinatorial constraints". Dynacom uses the notion of 'institutional comparative advantage' within this context. **If a European model of 'institutional comparative advantage' is seen in a combination of *some* harmonised institutional arrangements at European level with a great deal of institutional diversity at other levels, it is crucial to identify those aspects that should be tackled in a harmonised manner.** The projects reviewed give some indications which aspects tend to be of a cross-cutting nature and could benefit from harmonisation.

Two general lessons can be learnt from these considerations. First of all, one can conclude that **coordination mechanisms are needed to achieve institutional coherence** that allows to exploit the diversity of innovation systems and the benefits of harmonisation in specific fields, such as the tax system. This is a topic that will be tackled more broadly in the section on governance of research and innovation policy. Secondly, in order to devise such coordination mechanisms, **it is essential to have differentiated understanding of the institutional arrangements that shape innovation at regional and sectoral levels.**

Main policy messages

1. Europe's institutional arrangements for research and innovation suffer from two related shortcomings: Institutions are not sufficiently differentiated to fully exploit the differentiated nature of sectors and regions. At the same time Europe lacks harmonisation with respect to some of the basic institutions that should provide common settings for research and innovation and thus help reduce transaction costs, provide large unified markets and enable mobility within Europe. What is needed is a combination of harmonised institutional arrangements for some issues and of differentiated institutional arrangements at sectoral and regional/national level for others.

2. As reflected in the selective presence of MNEs, the attractiveness of regions depends on their ability to offer advantageous conditions for research and innovation that are firmly embedded in the regions institutional arrangements or other locally bound endowments. Policies aimed at enhancing a region's attractiveness in a sustainable manner should focus on (i) the development of specific strengths that are institutionally embedded and (ii) the exploitation of localised increasing returns and spill-over effects. This could be achieved, for instance, through the development of networks and competencies, the uptake of the opportunities associated with technological districts/clusters, and the nurturing of cultural diversity in cities.

3. The impact of general or horizontal innovation policies may differ drastically across sectors. An undifferentiated application of these policies without taking into account sectoral specificities may even lead to counter-productive effects. For instance, the relevance and role of cooperation and networking, i.e. of two primary policy targets in line with the conventional innovation systems approach, differs across sectors. This also puts into question the general usefulness of instruments aiming at enhancing cooperation in networking in *all* sectors. The sectoral perspective also stresses that more is needed than technology and innovation policy to foster innovation and diffusion, but rather a broad portfolio of policies, comprising for instance demand-oriented policies like regulations and procurement.

4. The importance assigned to sectorally specific determinants does not exclude common European approaches to shaping their institutions and frameworks. On the contrary, sectorally differentiated, but Europe-wide harmonised institutions and policies could help exploit the potential "economies of scale" of research and innovation inherent in many industrial and service sectors.

5. Existing sectoral systems can be governed predominantly by market forces. However, due to the strong path-dependencies at sectoral level, the development of new sectoral systems of innovation could be speeded up by an active policy approach, operationalised in the coherent application of a wide spectrum of instruments in early phases of system development.

5.4 Human capital, labour markets and innovation: the role of the individual

Human capital has become a major subject of debate within management, research, public and politics in the last years, with discussions focusing on how to maximise the contributions of people to the economy. This section discussed three aspects, which were addressed by some projects reviewed: (i) the role of flexible labour markets in innovation, focussing in particular on different organisational strategies and arrangements; (ii) important factors which could enhance life-long learning; and (iii) entrepreneurship as a core function for individuals in the knowledge based economy. Flexible labour market and lifelong learning are seen as necessary - partly alternative responses - to globalisation, structural change and fast technological progress. Trade unions can thereby play an important role to respond to these new challenges. Entrepreneurship is increasingly required in order to exploit the opportunities of new technologies, adapt to changing requirements, and often simply to meet employability expectations. Entrepreneurial activities are seen as a possible way of individuals in highly flexible labour markets to achieve self-employment and adapt to change. Specific reference will be made to the role of entrepreneurship for inducing innovation and economic development in peripheral regions which is addressed by TELL.

Labour markets and life-long learning as important factors for enabling innovation

The impact of flexible labour markets on the innovation performance of firms is to date still unclear. Flexibility might be advantageous for certain types of firms or sub-sectors but may at the same time lead to social inequalities, phenomena of marginalisation, social strife and may even harm innovation capabilities and long-term competitiveness. Education, training and lifelong learning are necessary elements for securing flexibility, but they do not necessarily require highly flexible labour markets. LEARNPARTNER, AITEG, Dynacom and Flex.Com deal with this topic and develop a more systematic understanding of the linkages between flexibility and innovation performance.

Many theories already explore the relationship between labour market flexibility and its impact on economic performance. Neo-classical economic theory argues that labour market flexibility promotes employment and growth. Other theories question this position and argue that (under specific conditions) increased labour market flexibility may harm economic performance and growth, especially the innovative performance of firms and nations. The theory of induced technological change, evolutionary theory, efficiency wage theory, demand-driven models of technical change, the endogenous growth model and theoretical approaches in management and industrial relations deliver alternative views and explanations for the

impact of labour market flexibility on economic performance. From the evolutionary perspective, for instance, flexibility might jeopardize variety and selection and thus harm innovativeness and competitiveness. Flex.com aims to draw a more differentiated picture of the relation between the characteristics of labour markets, economic performance and innovativeness based on this theoretical background.

LEARNPARTNER takes a critical look at the European Employment Strategy (EES) which stresses the importance of greater labour market flexibility. However, it is not necessary that labour market flexibility will contribute to high employment. Through flexibility the balance of responsibility for employment shifts from institutions to individuals who need to look after their employability mainly though life-long learning and skills-upgrading. The pillars of the EES are employability, adaptability, entrepreneurship, lifelong learning and equal opportunities, and the White Paper on Education and Training (EC 1996b) calls for a Learning Society "centred on the individual". This will be effective in fighting unemployment only to the extent that unemployment is due to a mismatch between skill levels and vacancies.

The impact of increased labour market flexibility on innovation and economic performance is contingent on the type of the firm, size of the economy and the time-horizon considered. Flex.Com distinguishes between numerical and functional flexibility. Numerical flexibility concerns the ability to adjust the quantity of labour inputs to meet fluctuations in demand by avoiding fixed and long-term work contracts. **Functional flexibility refers to the ability to deploy labour to a changing set of tasks.** Firms are pursuing this strategy by methods such as teamwork, job rotation, delegation of responsibility, etc.

Flex.Com delivers national case studies which analyse the labour market legislation, institutions and policies in the Netherlands, Ireland, Greece, Finland and Switzerland in the last three decades. These countries followed very distinct policies with different experiences and success patterns, and their labour markets, institutions and policies are different in terms of flexibility. In the last few years countries such as Ireland and the Netherlands followed a 'flexicurity' strategy, involving increased flexibility together with enhanced security for atypical workers. The Netherlands provide a reference model for a corporatist system of labour relations with highly flexible labour markets. Econometric analyses reveal that a decline in technological progress can be attributed to the slowdown in wage growth which was part of the policy of labour-market deregulation. Although in the Netherlands an exceptional employment growth (including many part-time jobs) was achieved in the last three decades - in line with a slowdown in wage growth - at the same time a decrease of labour productivity and technological dynamism could be observed. Kleinknecht and Naastepad (2002, 28) from the Flex.Com project conclude: *"… though labour market flexibilisation has increased employment, it has not resulted in higher GDP growth, because the positive effect on employment was almost fully offset by a decline in technological dynamism resulting in lower labour productivity growth."* In contrast, the case study of Ireland found that there was little relationship between increased labour market flexibility and the good economic performance and catching-up of Ireland. With an above average productivity and growth rate in the 1990s, Greece's amendments to introduce (mainly numerical) flexibility were only partly successful due to a relatively large informal sector and resistance to change.

Switzerland and Finland may serve as examples of how to improve on functional flexibility. Switzerland tried to focus on flexible workplace organisations with the aim to utilise 'functional flexibility' to successfully realise its high-technology, service and niche-strategy.

With a moderate wage growth accompanied by a quite flexible labour market which has not changed dramatically in recent years, Switzerland managed to keep its competitiveness. Switzerland is a case where the necessary preconditions for increased flexibility have been achieved through a high educational level, job-related training, intensive use of information technologies, and wide-spread, flexible organizational practices at firm level. Finland invested considerably in lifelong learning in the 1990s, and this enabled a high level of functional flexibility. GDP growth and innovative performance has been impressive, but the unemployment rate was rather high. Clearly, increased flexibility was one important element of the economic performance and growth of Finland. The consensus between the industrial partners to increase flexibility was achieved through active involvement of industry and labour market institutions in technological policy formulation and implementation.

In order to study the relationship between labour flexibility and innovation it is also interesting to consider different strategies pursued by firms. AITEG shows that 'low road' human-resource management (HRM) practices, which are characterised by short term contracts and low investments in training, are negatively correlated with investment in R&D and new technology, whereas 'high road' work practices which are associated with functional flexibility, are positively correlated with R&D investments and the introduction of new technology. Looking at the UK's Workplace Industrial Relations Survey (WIRS), AITEG researchers delivered evidence that the strategy to increase 'employment flexibility' by short-term contracts, weakening trade unions etc. does not improve the innovation performance of firms. This study, like other studies in the literature, argues that in the knowledge-based economy training investments and advanced HRM practices which, in turn, also facilitate flexibility are the prerequisites for fostering innovation and realising the productivity potential of new technologies, such as information technologies or advanced manufacturing technologies.

All in all, the empirical data analysed by the Flex.Com team shows that increased flexibility alone is not sufficient to reach superior economic performance. AITEG similarly concludes that there is **little evidence that either wage levels or "rigidities" can explain much of the employment change within Europe** in the last century. In a similar vein Dynacom researchers argue that countries with structured or rather rigid labour relations such as in central and northern countries do not necessarily harm the introduction of organisational innovations that increase flexibility.

Introducing functional flexibility is problem for many countries. To increase functional flexibility, firms use new ICTs and new forms of workplace organization, which requires a highly skilled workforce. Clearly, this is especially difficult in low-wage countries. Within this context, teamwork, even though difficult to implement, has become in some countries, for instance as LEARNPARTNER shows for the steel sector, an appropriate strategy to foster learning and to set incentives at the individual level. Though, as Dynacom researchers point out, there is an increasing divergence between numerical and functional flexibility within Europe which goes generally hand in hand with a low level of the diffusion of organisational innovations.

Strategies to increase flexibility are best implemented through a dialogue between the industrial partners. Unions can and do enable the development of learning agendas by identifying skill gaps, mediating between the workforce and the management and by establish partnership-based approaches to learning. However, trade-offs and tensions exist between increasing flexibility and some traditional aims of unions. According to LEARNPARTNER **the support of trade unions is crucial for expanding lifelong learning approaches**, but the

establishment of new role models for the unions still requires further debate. Trade unions need to get engaged in social movements that go clearly beyond their traditional activities. In many countries and sectors, trade unions contribute actively to the fostering of life-long learning. The case studies show that trade unions engaged within learning partnerships have been effective in activating employees from non-traditional backgrounds that have had little experience of learning since the completion of formal schooling. However, such partnerships create a series of challenges with respect to skills of local officials and their abilities to sustain such initiatives. So far, the role of trade unions as organisations supporting lifelong learning has been rather 'under-developed'.[12]

Even though policy-initiatives have been launched to support lifelong learning in most European countries, coherent national systems of lifelong learning with clear linkages between education, training and learning still need to be fully established. Moreover, due to the different national systems and traditions, it is not possible to formulate straightforward policy aims for the European level. In this context, the main conclusion of the Flex.Com project is that Europe needs a more diversified approach to enhancing flexibility. The researchers (Flex.Com final report, p. 6) conclude: *"There is no doubt that more flexibility is needed, but what is more difficult to ascertain is of what kind and for which particular situations."*

Opportunities for Entrepreneurship

Entrepreneurship is an important factor in structural change, creation of employment and transformation of human capital into economic activity. Entrepreneurial attitudes are increasingly regarded as a pillar of the knowledge based economy which should create new opportunities to commercialise technologies, support structural change, and create new jobs. The call for entrepreneurship demands new skills from individuals, graduates, employees and unemployed. Moreover, entrepreneurship is affected by the characteristics and flexibility of labour markets.

FERP deals with entrepreneurship in rural areas and delivers lessons for factors influencing entrepreneurial dynamics. Studying entrepreneurs in Germany, Poland, Portugal, Greece, and the United Kingdom, FERP finds five sets of common characteristics across rural areas: i) the over-representation of males, ii) younger age, iii) the acquisition of higher education qualification, iv) entrepreneurial influences by the parents, and v) previous experience of running a business. Inward migration appears to be a very powerful source of entrepreneurial talents in all regions, while outward migration deprives rural areas of talented individuals.

Looking at the strategy and development path of newly founded dynamic firms FERP found that the **majority of businesses have a strong local embedding with respect to physical and personal resources used**, but only a few take advantage of local know-how. In these cases the production of regional labels and local products has become an important business case, which also has a positive impact on the image of a region (e.g. 'healthy', 'traditional', etc.). Moreover, the internationalisation of businesses is weak and the factors influencing the establishment of this type of firms are somewhat unclear. In general, the use of new technologies but also lower costs, are both crucial to compete successfully. Finally, firms are

[12] Furthermore, as LEARNPARTNER concludes, there is also mismatch between the understating of newly propagated concepts such as the learning organisation. In this case employees often associate the idea of a learning organisation with the creation of organisational democracy, while the management wants to keep the structure of the organisation with its prevailing power structure. Up to now the learning society and learning organisation have not been developed.

rather passive towards innovation, whereas a more competitive context implies more proactive behaviour, as German regions demonstrate. Small local markets, a poor business environment and a lack of technical infrastructure are obstacles for entrepreneurial activities.

FERP delivers evidence that **national characteristics influence strongly entrepreneurial activities in rural areas, more so than industry specific factors**. According to FERP, the difference in business performance is more significant between countries than between different regions within a country. Entrepreneurial activities are diverse and path dependent in rural areas, some of them are distinctly rural, others occur more or less incidentally in the countryside.

The key message of the research team is that rural development policies should focus on the entrepreneurial human capital in the countryside. An key objective is to develop a supportive environment which holds and attracts entrepreneurial talents. Young people, in-migrants and leading figures/animators are potential sources of entrepreneurship. More specifically, direct measures such as business support, assisting regional marketing, facilitating linkages with organisations outside the region, etc., and indirect measures such as projects to build up infrastructure, social infrastructure, etc. are equally important. Moreover, given the fact that the national context is particularly relevant, policies have to be developed and implemented at the national level.

Analysing current policies, the team found that i) existing policies are often provided in a disjoined and fragmented fashion, ii) there is a poor level of dissemination of knowledge about rural firm development, and iii) some policies miss their target because of a poor understating of the local context. All these indicate weaknesses in policy support, and could be addressed by a more strategic and coordinated approach at the European level.

Main policy messages

1. Although often argued too in many public and political debates, there is no empirical evidence of a direct relationship between more flexible labour markets and economic performance, or of a direct link between flexible labour markets and innovation. There is evidence that too much labour market flexibility could be harmful to innovativeness.

2. Attempts by policy to improve 'numerical' flexibility in labour markets, combined with enhanced social security have shown to be effective for reducing unemployment rates, but constrain wage growth, and there is some evidence that they may constrain innovation.

3. Advanced innovation strategies require highly motivated and trained employees and new ways of working in environments characterised by organisational and functional flexibility. Functional flexibility requires highly trained people, and lifelong training is a crucial part of a strategy promoting functional flexibility.

4. Trade unions are very important partners in defining and implementing functional flexibility and lifelong learning strategies, even though the ability to facilitate these conditions is highly dependent on the institutional environment.

5. New forms of informal and formal labour relations will be required in the future, and policy has to support experimentation and the establishment of new forms of labour sharing and flexible arrangements across Europe, accompanied by the development of a shared vision for Europe's social model.

6. Entrepreneurship is an effective way to enable structural change, create jobs and translate human capital into economic performance. Rural entrepreneurship requires a more strategic and coordinated approach towards building entrepreneurial capacity in peripheral rural areas. Emphasis on education and training, concern with attracting and keeping talented individuals in the locality, and active involvement of rural communities, enterprises, and economic development agencies are characteristics of successful strategies for rural entrepreneurship.

5.5 The governance of research, technology and innovation policy: rethinking the processes of political decision-making

Requirements with respect to the governance of RTI-policy have been changing over the past years. To a significant extent, this is a consequence of the changing characteristics of research and innovation processes in the knowledge society. The level of complexity and uncertainty in research and innovation has increased considerably. For example, issues such as sustainability require a long-term perspective on the role of research and innovation, and corresponding policy strategies that aim at transforming socio-technical systems. This complexity requires from RTI-policy to have a strategic orientation and is reflected in the growing interest in priority-setting and foresight.

At the same time, innovation is expected to contribute to addressing a wide range of policy objectives that go well beyond the classical growth objectives. The need to take other policy areas' objectives explicitly into account in RTI-policy implies a better coordination with these policy areas. Furthermore, the trust in the ability and willingness of public policy to take citizens' interests into account in relation to the emergence of new technologies has been declining, as a consequence of the lack of openness and transparency of government policy in important public policy issues involving primarily public safety concerns (e.g. nuclear energy, "mad-cow" disease, etc.).

Recent approaches to the governance of RTI-policy aim at dealing with three sets of factors: (i) demands to solve highly complex long-term problems and challenges, (ii) the limited ability of policy to manage such issues and (iii) the growing scepticism about policy interventions being in line with societal needs. This situation poses a serious challenge for the legitimacy and public acceptance of RTI-policy. Attempts have been made in recent years to tackle this challenge, both within the realm of government and with respect to the interactions between government and civil society. Different approaches to public participation and social initiatives have been tested, but it is still unclear whether they will really be taken up more widely to complement formalised processes of decision-making. Within government, the notions of policy coordination and policy learning have gained prominence as a means to achieve greater coherence of different policies affecting a problem area (OECD 2005). In this section, the coordination between RTI-policy and sectoral policies and the self-monitoring of policy impacts are of particular interest.

Recent developments in participatory RTI-policy-making

There is little doubt that social initiatives in democratic engagement (like e.g. consensus conferences or national consensus debates) have become more widespread in Europe, starting from first experiments in countries like Denmark in the early Eighties. However, in spite of regular intentional statement at national and European level to replace the still dominant "neo-classical market mode of governance" by a more deliberative mode, it would be premature to speak of the emergence of a new European paradigm of scientific governance. In view of empirical evidence of actual "on the ground" and lived experience of policy formulation and enactment, it would not be plausible to suggest that a new paradigm of engagement has replaced more familiar modes of governance and institutional action.

In fact, we can observe a lot of diversity in practices of governance of policy debates on science and technology. This diversity is reflected in the typology of governance styles suggested by STAGE, which distinguishes six main types of governance modes:

- Discretionary, i.e. making little or virtually no use of interaction with the public;
- Corporatist, i.e. interaction is restricted to a well-defined and often closed community of stakeholders (although more open variants can also be found);
- Educational, i.e. emphasis is put on "educating" the public in order to close the supposed knowledge gap between experts and the public.
- Market, i.e. arguing that science and technology choices can be governed through the economic mechanisms of demand and supply;
- Agonistic, i.e. where confrontation and adversity prevail in political debates about S&T, often leading to a loss of control and stalemate;
- Deliberative, i.e. based on a strong public involvement and support from a continuous public debate of and engagement with science.

Although national styles of governance may favour the one or the other mode, in most countries several of these modes can be found. Europe, as highlighted by STAGE, is characterised by a distinctive culture of scientific governance where new questions are being asked and issues of science, society and innovation have indeed become more common concerns in policy-making. Matters of RTI-policy have become more central to political and institutional action within Europe, and it is increasingly accepted that public engagement and support are imperative in this context, and not only for reasons of legitimacy of policy decisions but also to ensure an effective coordination and implementation of distributed actions.

New approaches to the collective management of long-term challenges to society (like for instance sustainability), which tend to require structural and institutional changes ("regime shifts"), stress the necessity that the strategies and actions of all the major actors and stakeholders are better coordinated and oriented towards common societal objectives or visions (Kemp/Rotmans 2005). First experiences with this kind of approaches have nurtured the hope that participation could enhance the ability of society to cope with complexity, uncertainty and ambiguity in a long-term perspective.

In spite of the undeniable potential of deliberative exercises, it is necessary to be realistic in terms of the expectations associated to them. Experiences so far have shown that participatory processes do not necessarily lead to superior outcomes of processes of policy formulation. The influence is multi-facetted, indirect and complex. Neither can the deliberative mode in itself settle public concerns about the direction of socio-technical change. Although deliberative exercises are often used as a means to soften antagonistic debates, to overcome

stalemate or to avoid anticipated conflicts, these hopes of reaching consensus are not confirmed by many of the case-studies in STAGE. However, **as a means to empower a culture of scientific citizenship, deliberation seems uncontested.**

Policy coordination and policy learning

The environment for research and innovation is changing very fast. Globalisation, the volatility of investments and the widely perceived acceleration of knowledge production imply a need for an enhanced ability of innovation systems, of institutions and of firms to respond quickly and adapt to developments in their environment. As stressed in WEST-EAST-ID, POSTI, TELL and TENIA, this requires also from RTI-policy an enhanced ability to adapt.

A pre-condition for effective adaptation consists of the ability to assess the impact of policy actions. However, as indicated in Section 4.1., impact assessment, especially with respect to multi-dimensional and long-term objectives, is confronted with serious methodological difficulties of observation, (output) measurement and identification of cause-effect relationships. To these add challenges of having to adjust policies to new emerging challenges in a fast changing environment. An iterative approach, based on principles of continuous monitoring, and adaptation is thus required, adjusted to the specific requirements of the national, regional or sectoral systems in question.

This **need for policy learning within RTI-policy is reinforced by growing demands from other policy areas on RTI-policy to ensure that research and innovation contribute to solving major problems tackled in these policy areas**. It has increased the need for better coordination between policies. This point has been made by the ESSY project. The sectoral perspective on innovation systems calls for a more targeted consideration of a broader range of policies than in the prevailing national innovation systems approach. An undifferentiated application of innovation-related policies could even be dangerous, because they can lead to very different outcomes depending on the institutional arrangements and innovation practices in each sector. The need for a better coordination of RTI-policy with sectoral policies is also stressed by strategies that aim at long-term transformation processes of sectoral systems of innovation and production. Especially the re-orientation of sectoral systems towards principles sustainability requires structural and institutional changes that touch upon a broad range of policy areas.

Despite the widely recognised need for better policy coordination, in practice there are major difficulties. Established organisational interests of public administrations represent a major challenge to an effective coordination. A balance needs to be struck between better coordination on the one hand and the limitation of transaction costs associated with coordination on the other. Organisational and process-based solutions need to be devised to tackle these problems.

Main policy messages

1. Deliberative processes have been tested in several instances over the past twenty years, but it is still unclear to what extent they can really become a major shaping factor in policy-making. For deliberative processes to be effective, it is essential that they are very explicitly framed. It must be clear what questions they should answer, what sources of evidence are necessary, how the processes of achieving results is organised, and how the results will be taken on board in policy-making.

2. There is a clear need to improve the ability of RTI-policy to adapt to fast-changing requirements in research and innovation, but also with respect to other levels and other areas of policy-making. This requires new mechanisms to improve the coordination of policies around sectoral or thematic domains, establishing continuous policy monitoring mechanisms, and reinforcing an output-oriented performance assessment as pre-conditions for policy learning.

6 Implications and requirements for research and innovation policy

In this last chapter we take a look at the cross-cutting lessons to be learnt from the partial insights of the individual projects reviewed, at the conclusions and requirements they raise for research and innovation policy in particular, and at some major research questions that will need to be tackled in the coming years.

While a number of new and interesting insights into the changing nature, the determinants and the impacts of innovation can be extracted from the projects, explicit conclusions with respect to RTI-policy at European level are rather limited. The projects deliver some innovative (and some critical!) empirical and theoretical contributions to the four main policy debates highlighted at the beginning of this report, but – as expressed for instance in the Dynacom and TELL projects – they do not aim at delivering policy recipes, but, at best, at flagging problems and dilemmas policy is facing and presenting new perspectives in a reflexive and discursive way. Some projects suggest concrete and detailed policy conclusions and measures, but in such cases it has often been difficult to trace the link between the research findings and the policy conclusions.

In order to present the policy conclusions we first will summarise the lessons learned with respect successful innovation processes in the context of the move towards a knowledge-based society. Then we will take a look at new, mainly empirical insights into the innovation performance of Europe, and at the ability of the European innovation system to provide the necessary institutional settings for enhancing the innovation performance. We will then point out some major policy challenges for the future, and finally explore future research needs.

New perspectives on successful innovation in the knowledge-based society

The projects under review dealt with the nature and dynamics of innovation processes in the economy from the perspective of social and economic sciences. All 20 projects delivered theoretical contributions and empirical evidence for successful innovation activities of firms in various sectors, regions and countries and aimed to identify optimal conditions and enabling factors for innovation. Based largely evolutionary economics, modern firm theories, institutional economics and the heuristics of innovation systems, the main pillars for successful innovation can be sketched as follows:

- *Innovation has always to overcome (new kinds of) barriers within and outside the firm:* Innovation and learning are hampered by lack managerial competencies, lack of the access to human resources and finance, and weak appropriability of knowledge. Technological competences, organisational competences, and the ability to use external knowledge sources are highly significant for economic success of business firms. For global firms internal knowledge transfer and adaptation to different locations is crucial to absorb new knowledge while SMEs are especially affected by their major (lead) customers and suppliers. Innovative and non-innovative firms are embedded in institutional settings which provide the necessary conditions and incentives to develop and launch new products and processes. Even though policy can reduce uncertainty and eliminate certain types of barriers, the nature of innovation demands always to cope with new barriers and challenges.

- *Organisations and institutions as interdependent entities:* The innovation systems approach and similar concepts are the dominant heuristics used to understand the complex interplay of organisations and institutions and deliver rationales for policy interventions. Actors, networks, knowledge domains and institutions constitute an innovation system. The innovation system approach identifies the roles, functions and activities of the different actors within a given system: co-ordination, IPR, intermediaries, developing scientific knowledge, guiding research, providing human resources, financing innovation, reduction of risk, and the diffusion of knowledge are important functions performed by the various actors. Aggregate demand, labour market conditions, country specific institutions, social relations and macroeconomic conditions are significant for creating the conditions for a positive impact of technological change on employment and economic change.

- *Variety and diversity as sources for innovation:* For an organisation, internal and external variety and diversity are sources and necessary preconditions for innovation. This should be a key concern for targeted policies that often trade diversity off for uniformity, manageability, transparency and efficiency. Variety has to be understood in a broad manner including scientific, technological, sectoral, regional and cultural diversity.

- *Continuous organisational and institutional change as fundamental success factor*: Organisational innovations, flexibility and adaptation are more than ever important prerequisites to fully exploit the potential of new technologies. Advanced innovation strategies require highly motivated and trained employees and new ways of organisational and functional flexibility. The possibilities for organisational innovations are strongly influenced by the institutions such as the industrial relations or governance mechanisms within the economy. Both complements each other and have to fit in order to sustain superior performance on the micro, meso or macro level.

Europe's innovation performance and its preparedness to embrace with the knowledge-based society

Based on the mainly empirical evidence provided by the projects considered in this review the following strength and weaknesses of Europe's innovative performance can be identified:

- *European firms tend to perform less well in "new sectors" where emerging disciplines offer opportunities for new product and service development* such as biotechnology, internet and some sub-sectors of ICT. Moreover, Europe has a weakness caused by the lack of young entrepreneurs in new technological fields. One exception, where Europe was successful in the last few years is in some sub-sectors of telecommunications, where due to a co-ordinated effort between innovative firms, regulation and public organisations Europe was able to develop GSM. But even there, new applications and new technological generations will set up a new game. In service industries Europe is still not able to exploit the full potential master the transition to more "hybrid sectors".

- *Regarding the internationalisation of R&D and innovation*, which is driven mainly by MNC, some research reviewed here illustrates that the largest European MNC influence the integration process within Europe. Though, at the same time, European MNCs compared to US MNCs are less able to exploit the knowledge acquired abroad. Thus, with respect to so-called 'reverse technology transfer' European MNCs seem to lag behind competitors. Moreover, AITEG concludes that Europe is lagging behind with respect to the globalising learning economy.

- *The "European paradox", namely Europe's apparent inability to transform its scientific and technological strength in many areas to competitive performance, is a major weakness.* Dynacom concludes for instance within this context that European firms have probably lost some of their innovative edge due to less rich opportunities of local scientific advances, especially in pharmaceuticals and information technologies (with the exception of the mobile telephony sector). In contrast, Europe is still strong in areas where the preceding technological paradigms dominate knowledge production, such as mechanical engineering, chemicals and transport equipment.

- *Framework Programmes helped to built up R&D and innovation network between various actors across Europe* in the last years. These are quite heterogeneous consisting of a few agents with many ties and a lager number of agents with few ties. Empirical analyses suggest that in mature technological fields (ICT) established leaders and networks have been reinforced by the FP programme, whereas, for instance, in Medical Technology and Biotechnology the configuration of new innovative networks has been fostered. Even though there had been large efforts to foster scientific strength across Europe by FPs, Dynacom researchers argue that EU-sponsored research had a disappointing effect upon technological competences. In general, a relative small number of organisations, including some large firms, some universities and public research institutions have become major players in the European Research Area.

- *In the last years some regions were able to become successfully 'leading regions' in certain technological fields across Europe due to agglomeration effects, spill-over generation and co-ordinated actions between private and public actors*. The case of the ICT sector in Denmark shows some evidence of agglomeration effects and increasing regional specialisation, which has been facilitated by the process of European integration. Specific institutional factors have attracted MNC, which in turn strengthen the regional innovation system. At the same time, as AITEG research stresses, the gap between advanced and backward regions has become wider, mainly through MNCs' technological activities.

- *Institutional change in Europe is often overly slow and difficult especially in relation to industrial relations*[13]. Efforts to promote functional flexibility in firms and jobs are often hampered by structural, cultural and organizational factors such as lack of skills, established hierarchies, lack of trust to institutions, adversarial labour relations etc. Many countries find the implementation of such strategies difficult. In particular, the proactive role of industrial labour relations has to be fostered as factor which can enable change towards more flexibility.

- *The systemic nature of innovation continues to be a challenge for the European Union.* The linear model of innovation is still strong in European policy, where there is a strong focus on research investment and a relatively fragmented policy portfolio.

Key challenges for research, technology and innovation policy at European level

The analysis of recent findings on research and innovation processes in Europe sheds a new light on the main four challenges for European RTI-policies as formulated in the introduction: Competitiveness, Sustainability, Employment, and Legitimacy. In the following, important

[13] It is recognised here that rapid institutional change is not necessarily desirable. The point made by the research is that, especially in the case of the promotion of functional flexibility, institutional inertia is often counter-productive for all involved.

implications for policy on the European level will be synthesized. Obviously, these topics overlap and some policy implications mentioned address more than one challenge.

With respect to *Enhancing competitiveness and innovation* the following implications can be raised:

- *Strengthen unique combinations:* Rather than just trying to "strengthen the strengths", RTI-policy in Europe should rather be guided by the notion of "building unique combinations". This requires to build on existing strengths, but also to exploit their combination with new emerging developments in science and technology. This indicates why it is necessary to maintain diversity in research and innovation, as well as in institutional arrangements. For European strengths to develop a harmonised framework of policies is necessary, especially when it comes to exploiting economies of scale in near-market environments. Trade unions and related institutions are important (local) actors providing continuity and supporting adaptation.
- *Build the institutional basis for variety creation:* Universities and Public Research Institutions are major knowledge sources in innovation systems and as such a key argument for MNEs and other firms to invest in a specific location. It is necessary to strengthen the ability of the S&T system to generate a pool of knowledge and innovation opportunities. If this function is to be effectively met, flexibility and autonomy in the definition of research topics have to be incorporated and combined with stable framework conditions and clear incentives for successful innovation.
- *Recognize the growing importance of intangibles and a flexible labour force:* Organisational innovations, intangible assets and complementary investments in training and the continuous development of individual skills are still underestimated in Europe. Institutions and organisations such as training systems and trade unions need to play a more prominent role for enabling the widespread and flexible exploitation of intangible assets and investments, whereas firms have to be supported to absorb and use external knowledge and learn how to make use of the potential of intangibles.
- *Increase the specificity of RTI-policies:* Innovation systems are still strongly influenced by national-level institutions, but the changing nature of knowledge production indicates a growing demand for regionally and sectorally specific institutional arrangements and corresponding policies. This has far-reaching consequences for the design of the Framework Programme and its allocation and selection mechanisms (for instance in terms of additional criteria), but also for the design multi-level coordination mechanisms in RTI-policy (which tend to be very much sector- or theme-specific anyway).
- *Realise complementarities between harmonisation and diversity:* National and regional channels of knowledge flows are deeply "rooted" in countries and regions. The regional and local diversity in Europe offers a wide variety of combinations of factors and conditions that have to be exploited by supporting the *local and regional* networking of firms and research organisations in the context of R&D funding and innovation policy. At the same time, harmonisation within a European Innovation System in terms of the basic institutional settings and the creation of large common markets would allow exploiting economies of scale and improve Europe's attractiveness as a location for research and innovation. Exploiting these specific conditions of diversity requires a European way of RTI-policy rather than copying models from overseas.

With respect to *Creating employment* the following policy implications can be synthesised:

- *Stimulate product and radical innovations:* If innovation is to lead to more employment, research and innovation have to be supported in sectors that are characterised by a potential to lead to product innovations and radical innovations. Policy approaches need to be developed, both at national and European level, that are sensitive to the difference

between process innovations on the one hand and product innovations on the others. Thus, policy has focus on industries with high rates of product innovation such as KIBS in order to foster employment creation.

- *Counteract the erosion of the industrial base and stimulate the emergence of new industrial and service activities:* There is a risk that the industrial base in Europe could be eroded in the course of Europe's comparatively slow transition to a knowledge society and the growing competition emerging economies. This process not only concerns established industrial sectors, but also services and new "hybrid" industries. Some policy approaches tend to be conducive to employment in some sectors, but detrimental to employment in other sectors. Timing is significant. Europe's traditional industries will soon be affected by the new requirements of the knowledge based society, and policy and industry would need to react quickly in order to exploit the opportunities for employment creation in new emerging sectors. For innovation policy measures to be effective with respect to employment, it must pursue a differentiated approach that is geared towards the specific conditions of industrial sectors (including emerging ones) and take a long-term view that allows overcoming short-term vested interests and associated claims for protectionism.

With respect to *Ensuring sustainability* the following implications can be raised:

- *Induce and guide long-term transition processes:* Sustainability is a necessity and an opportunity, but it raises major challenges to policy. Long-term and adaptive policy strategies are needed to guide transition processes of structural and institutional change. Participation and involvement of actors and stakeholder in an iterative collective learning process are necessary to ensure the coherence of these transitions, and serve as a means to enhance policy coordination and learning.

Finally, with respect to *Ensuring legitimacy,* the following suggestions are stressed:

- *Improve coordination of RTI-policy*: There is a growing demand for coherence between industrial, RTI-, education and macroeconomic policies, as well as between RTI-policy and sectoral policies, both at individual policy levels and between them. Especially RTI-policy needs to be focused on employment friendly innovations, public and private users, and knowledge-intensive ICTs. The concept of knowledge regimes and knowledge coordination failures helps to design specific policy measures.
- *Recognize the limitations of targeted policy intervention and impact assessment:* Clear rationales and justifications are needed to justify policy interventions and public investment in research, technology and innovation, and not only due to budgetary limitations but to also to avoid inefficient or even counter-productive impacts. Targeted policy interventions are bound by the inherent complexity of innovation processes, and so is the ability to foresee the impacts of policy interventions. Policy needs to recognise these limitations to steering and ex-ante impact assessment. Rather, policy should concentrate on functions of moderation, stimulation, and inducement of structural and institutional changes, embedded a framework of strategic anticipation, adaptation and policy learning.
- *Foster participation in RTI-policy making:* The processes leading to the definition of RTI-policy need to be reconsidered in the light of the governance principles set out in the Commission's White Paper on Governance. A higher weight should be assigned to participatory approaches to the *preparation* of policy strategies, even if the final decisions remain in the hands of those who are constitutionally empowered to take them. This development is compatible with the aforementioned demands for better policy coordination and learning, and it needs to be combined with exploratory, but goal-oriented anticipation with respect to science, technology and society ("foresight"), thus recognising that future developments in science and technology are a matter of societal choices and governance.

- *Improve the credibility of European policy:* If the Lisbon agenda and the associated RTI-policy objectives are supposed to be credible, the European institutions must turn into best-practice examples for the kinds of demands and initiatives they raise. So far, the handling and administrative implementation of European policies – both internally and externally - severely contradict the principles of flexibility, innovation-friendliness and participation that are proclaimed by exactly these policies.

Future research needs

The analysis of the socio-economic projects which refer to questions of research, innovation and technology policy allows to identify future research needs in the following areas:

- The innovation systems approach is still the dominant framework for the analysis of innovation patterns, and the corresponding market and systems still represent the main justification for research and innovation policy.[14] A *new generation of conceptual and theoretical frameworks* is needed that recognises the complex nature of innovation processes.
- While growth and employment figure prominently in the projects reviewed, there is hardly any reference made to the notion of *sustainability in relation to innovation*. In spite of the importance sustainability has acquired as a cross-cutting issue in policy-making at European and Member State levels, long-term development issues tend to be ignored in innovation research. The merging of the corresponding research communities around corresponding European projects would help shift the attention to these long-term challenges to European society.
- Impact assessment is an urgently needed element for an adaptive, learning-base RTI-policy, but it will not work on the basis of simplistic quantitative tools. Instead, *impact assessment requires a more sophisticated heuristic that builds on a framework for coping with uncertainty and complexity*, and a consolidated understanding of the employment and sustainability effects of innovation.
- As a precondition for impact assessment and adaptive strategies, the *measurement of innovation must be based on a broader concept of innovation*. Current measurement of innovation is inappropriate for the broader meaning of innovation in the knowledge-based society.
- Policy approaches and strategies, geared towards the *adaptive management of long-term transition processes* towards long-term societal goals such as sustainability and the building up of new industries, need to be developed and tested. These strategies need to combine elements from RTI-policy as well as from other policy areas.
- While the importance of diversity and of institutional arrangements is widely recognised, the way ahead is much less clear. The aggregate implications of maintaining a higher degree of diversity in Europe need to be investigated. Moreover, a specification of the general claim for a better balance between diversity to ensure innovativeness in the long-term on the one hand and harmonisation of certain key elements of the European innovation system to exploit scale economies and large markets on the other.

[14] Since the "First Action Plan for Innovation in Europe" (EC 1996a) the innovation systems approach has become an important conceptual framework for formulating and legitimating research, technology and innovation policy.

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List of acronyms and abbreviations (excl. project acronyms)

CIS	Community Innovation Survey
DG	Directorate General
GDP	Gross Domestic Product
GSM	Global System for Mobile Communications
EC	European Commission
ERA	European Research Area
EU-15	The 15 (older) Member States of the European Union
FDI	Foreign Direct Investments
FP	Framework Programme
KBE	Knowledge-based Economy
KIBS	Knowledge-Intensive Business Services
IPR	Intellectual Property Rights
MNC	Multinational companies
R&D	Research and development
RTI	Research, Technology and innovation
RTO	Research Technology Organisations
SME	Small and Medium-sized Enterprises

APPENDIX: PROJECTS REVIEWED FOR THE REPORT

Project code	Acronym	Title	Leader
HPSE-CT99-00043	AITEG	Internationalisation, technology and employment in different geographical environments	Prof. J. Michie
SOE1-CT97-1077	CDIS	Comparative Dynamics of Innovation Systems	Prof. R. Barre
HSPE-CT99-00022	CoCKEAS	Coordinating Competencies and Knowledge in the European Automobile System	Prof. Y. Lung
SOE1-CT98-1078	Dynacom	Dynamic Capabilities Growth and Long-Term Competitiveness of European Firms: A Diagnosis and the Implications for EU Policies	Prof. G. Dosi
HPSE-CT2001-50007	ENGIME	Economic growth and innovation in multicultural environments	Prof. D. Pinelli
SOE1-CT98-1116	ESSY	Sectoral Systems in Europe: Innovation, Competitiveness and Growth	Prof. F. Marlerba
HPSE-CT99-00013	FERP	The future of Europe's rural periphery, the role of Entrepreneurship in responding to employment and social marginalization	Prof. L. Labrianidis
HPSE-CT2001-00093	Flex.Com	Flexibility and Competitiveness: Labour Market Flexibility, Innovation and Organisational Performance	Prof. L. Tsipouri
HPSE-CT2001-50011	HERN	Higher Education Reform Network	Prof. M. Guzkowska
HPSE-CT01-00047	IEEF	Innovation and Employment in European Firms: Microeconometric Evidence	Prof. J. Jaumandreu
SOE1-CT98-1118	KNOW	Innovation-Related Knowledge Flows in European Industry: Extend, Mechanisms, Implications	Prof. Y. Caloghirou
HPSE-DT2001-0049	LEARN PARTNER	Learning in Partnership: Responding to the Restructuring on the European Steel and Metal Industry	Dr. M. Stuart

SOE1-CT98-1079	METDAC	Managing European Technology: Defence and Competitiveness Issues	Prof. Healey
SOE1-CT98-1100	POSTI	Policies for Sustainable Technological Innovation in the 21st Century: Lesson from Higher Education Science, Technology and Society	Prof. Gronning
SOE1-CT98-1115	RISE	RTOs in the service economy – Knowledge infrastructures, innovation intermediaries and institutional change	Prof. M. Hales
HPSE-CT2001-00057	SETI	Sustainable Growth and Employment Creation in the Technological Integration of the EU Economy	Prof. Vuijsteke
HPSE-CT2001-5003	STAGE	Science, Technology and Governance in Europe	Prof. Waller
HPSE-CT2001-00051	TELL	Technological Knowledge and Localized Learning: What Perspective for a European policy?	Prof. C. Antonelli
HPSE-CT2001-00100	TENIA	The emergence of New Industrial Activities: Fusing Services and Manufacture	Prof. Y. Caloghirou
HPSE-CT2001-00098	WEST-EAST-ID	Industrial Districts' Relocation Processes: Identifying Policies in the Perspective of the EU	Ms. R. Sarcina

European Commission

EUR 23164 — EU Research in Social Sciences and Humanities
Policy Synthesis of EU Research Results – Series n° 7 : Research, Innovation and Technology Policy

Luxembourg: Office for Official Publications of the European Communities

2007 — 58 pp. — 21.00 x 29.7 cm

ISBN 978-92-79-07572-8

KI-NA-23164-EN-N

Publications Office
Publications.europa.eu

ISBN 978-92-79-07572-8