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Research Report

Achieving Lisbon: The EU's R&D challenge. The role of the public sector and implications of US best practice on regional policymaking in Europe

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BEITRÄGE DER HOCHSCHULE PFORZHEIM

Kim Dobbie Neuer

**Achieving Lisbon – The EU's R&D Challenge
The role of the public sector and implications of US
best practice on regional policymaking in Europe**

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**Achieving Lisbon – The EU's R&D Challenge
The role of the public sector and implications of US best
practice on regional policymaking in Europe**

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Kim Dobbie Neuer is an arts administrator in New York City. Passionate about culture, business and politics, Ms. Neuer earned an MBA in International Management from Pforzheim University. While in Germany, Ms. Neuer launched and piloted the first year of Prof. Dr. Dirk Wentzel's Pforzheim Summer School for US undergraduate students, produced several projects for SAP AG and assisted in the Policy and Regions center at Fraunhofer Institute for Systems and Innovation Research. She also co-wrote a highly ranked research proposal for the EU's Seventh Framework Programme as part of the University's partnership with Steinbeis Europa Zentrum. Ms. Neuer is currently Vice President, Finance at The New 42nd Street, Inc., which is charged by the economic development corporations of New York City and New York State with overseeing the revitalization of seven historic theaters in Times Square and operates The New Victory Theater, The New 42nd Street Studios and The Duke on 42nd Street. Previously, Ms. Neuer was in senior management with Hartford Stage Company, Chicago Shakespeare Theater, and the American Repertory Theater.

Preface

In 2008, as the end of the first decade of the 21st century drew nearer and before the onset of the current worldwide economic downturn, it seemed increasingly likely that the European Union would not achieve by 2010 the economic goals it had set for itself in 2000 under the Lisbon Strategy. Despite these formal goals and some pockets of exceptional performance, the EU was not benefiting as strongly from its R&D efforts as the US, Japan and Korea, for example. A keen interest in economic development as a whole and in the drivers of growth in particular led me to a closer look at the regional dimension. I quickly discovered that this area was the subject of study at Fraunhofer Institute for Systems and Innovation Research in Karlsruhe. I was privileged to work there with Prof. Dr. rer. nat. Knut Koschatzky and Dr. rer. nat. Thomas Stahlecker, where I developed case studies for US states using the regional typology identified by the Institute for the EU. Through comparative analysis, these case studies provided a framework from which the role of the public sector in stimulating R&D and the tools available to policymakers could be examined.

Kim Dobbie Neuer, December 2009

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Summary

In 2000, the European Council set its sights on becoming the world's top knowledge-based economy. To that end, they aimed to achieve a goal of spending 3% of GDP on research and development by 2010. Their Lisbon Strategy recommended a number of efforts on the European Union and national levels, including encouragement of public-private collaboration. Examination at the regional level indicates the need for R&D and innovation policy to help stimulate growth. Current theory turns attention to the effect of system failure in the regions. The Fraunhofer Institute for Systems and Innovation Research developed a typology for the regions of the European Union. Using performance results, this paper identifies US states that correlate to the typology. Comparative analysis of these states based on key industries and actors, major programs and instruments, successes, failures, impact of federal programs, and best practices then informs discussion of the implications on policymaking. If regional variances represent the most important factor influencing the development of an appropriate policy mix, local specializations, along with regionalized institutional factors, must be considered when codifying the main objectives for policymakers, such as stimulating the efficiency of the system, encouraging dynamic connection among the actors, and reducing the risk of lock-in. This, in turn, affects selection of the instruments that may or may not benefit the region and the indicators with which the impact of public action may be measured. Considering this, particularly challenging for the EU is the need to balance decentralization of action in the regions and coordination at the Union level.

Keywords:

JEL-Classification:

1 Introduction

The European Union relies on four freedoms to provide a solid foundation for its political and social value base, tying together its often-disparate members. These freedoms – free movement of goods, services, persons and capital – protect the internal market, which forms the basis for integration. Earlier this year at the Spring Council summit, a fifth freedom was featured – the freedom of knowledge, in keeping with the strategic objectives for the future economic health of the Union (Kubosova 2008).

These objectives were codified in Lisbon at the March 2000 meeting of the European Council. The heads of state of the then fifteen member states of the European Union (EU15), concerned about the increasingly serious challenges posed by globalization and the aging society and the effect on Europe's competitiveness in the world, emphasized the importance of keeping up in today's knowledge-based economy. Naming access to digital information, economic reform, education and research as key drivers, the Council set an agenda by which they would achieve global competitiveness, if not leadership, by the year 2010.

Setting in place a number of targets for the newly named European Research Area, the commission aimed to increase competitiveness through its science and technology policy, an emphasis on growth and jobs, and improved social cohesion. Thus were scientific, economic and social concerns, respectively, underscored and blended into an overarching concept. Numerous indicators were selected to measure the progress of the agenda on an ongoing annual basis.

Following recommendations from the European Commission, the European Parliament and the Economic and Social Committee, the Barcelona Council in March 2002 highlighted the important role of stimulating innovation¹ – defined as new knowledge used for technological innovation – in order to achieve sustainable results. To address the growing gap between the European Union and both the United States (US) and Japan in research and development (R&D), they set in place an objective of approaching gross R&D spending of 3% of gross domestic product (GDP) by 2010. In response, the Commission recommended efforts on the union level – including policy and framework organization to encourage human resource training and mobility, to protect intellectual property rights, and to establish common standards – and on the national level, including attention to tax incentives and disincentives for R&D, encouragement of public-private collaboration and improvement of access to capital.

While some ground may have been gained in certain areas, overall indications were disappointing over the first several years of the agenda, leading to a major review of the strategy in 2004. In November of that year, a report from the High Level Group found that Europe's R&D gap with North American and Asia had in fact increased. Refocusing of the strategy placed greater emphasis on economic growth and creation of jobs, particularly for women and older workers. Science and technology goals were distilled into a single target – the Union-wide goal that 3% of annual GDP be earmarked for R&D by 2010, with two thirds funded by industry. Also revision of the framework for allocating state funds for R&D and innovation was recommended.

In subsequent studies, the European Union and a number of independent groups focused attention on specific barriers and the techniques and tools needed to overcome them. Instruments to promote technology transfer from public to private knowledge users and the need for specific actions at the union level to stimulate regional results have been emphasized.

Today, as we approach the end of 2008, it is clear that the European Union will fall short of achieving its goal for 2010, and the message, while just as urgent, seems to have softened into more of a "pep talk" than an outright aim. To that end, in a 2007 summary from a European Commission policy strategy seminar, the 3% objective is referred to as "...an indicator rather than goal in itself...", and the report amends the figure to a very optimistic 2.6%, which is based on achieving the aggressive plans of individual member states (DG Research 2007b, 15).

While analysis has been undertaken to illustrate the outcome of non-Lisbon, there appears to be continued confusion over the centralization of a goal that has regional implications, and studies on the influence of public action on private investment are not entirely conclusive. Both the European Union and the national governments continue to look beyond their borders for best practice to influence their own activities, using the United States as a primary benchmark.

This paper looks at the 3% objective for R&D spending through the lens of regional policy and explores the effect of public spending on private actors with an eye toward best practice. To that end, section 2 provides a brief background of the Lisbon strategy and the renewed goals in order to introduce and contextualize the objective. Section 3 discusses monitoring and assessment and illustrates the real-world challenge by providing key figures relative to R&D results, introducing the

¹ While scholars often differentiate between research (or invention) and innovation, policymakers tend to address both together; therefore, they are not scientifically differentiated for the purposes of this paper.

importance of the regional dimension. Section 4 discusses sectoral composition and regional agglomeration as the foundation for recent trends in policymaking and details two leading approaches influencing the economic rationale for public intervention.

Section 5 presents the regional typology for the European Research Area developed by Fraunhofer Institute for Systems and Innovation Research. This typology is then applied in selecting four US states that correspond to these regional types. A short case study is provided for each of the four states, which identifies positive and negative performance results, key industries, actors and the primary instruments in place, followed by an analysis of the system. Section 6 explores the impact of the aforementioned on policymaking and outlines the process of matching policy instruments to identifiable regional issues. Finally, section 7 concludes with a round-up of lessons learned.

2 The EU's research and development objectives and establishment of the Lisbon strategy goal

2.1 Early objectives and action plans, 2000-2003

In 2000, the European Council met in Lisbon and stressed further development of the knowledge-based economy as the key to future competitiveness and thus to growth of the European Union (EU). As a result, the Lisbon strategy was set in motion, calling for a shift to an information society supported by a cohesive research area with appropriate mechanisms and an environment conducive to research and development (R&D) and innovation, integrated product and financial markets, and education and training. Action items included looking at national and regional policies, selecting measures and targets, and completing annual progress reviews at subsequent Spring Council meetings (EC 2000).

Just a few months earlier in a document entitled "Towards a European research area", the EU Commissioner for Research highlighted the need for coordination of national and EU level policies, especially given enlargement activities that were likely to make collaboration even more difficult (DG Research 2007a; Georghiou 2001, 891). The paper called for coordination of existing EU policy schemes and instruments within the newly formed European Research Area (ERA), a geographical and conceptual area created to support cooperation – a sort of internal market specifically for research (EC 2007b, 6).

Two years later at the Barcelona Council, specific objectives were quantified for R&D as a driving force to achieve the Lisbon goals. The Council called for a Union-wide R&D spending target of 3% of gross domestic product (GDP) by 2010. They stressed that this average could not be achieved by each country individually, thus implying that a coordinated effort would be necessary to ensure that strongly performing member states could make up for shortfalls in underperforming member states. Additionally, spending by the business sector was expected to account for two thirds of the 3% total and public support for the remaining one third. Calls to action focused on poles of excellence centered on public institutions, entrepreneurship, and improvement of conditions for skilled personnel, financing and other instruments within a supportive business environment (EC 2002).

These recommendations, among others, were laid down in an action plan in 2003 consisting of four key elements: coordinating with and between member states; improving the environment for R&D; focusing on public support; and increasing public funding. Of chief importance was the need to stimulate and improve public-private partnerships in order to address the gap between academic research and technology-based innovation and to create synergies among new and existing instruments such that the combination of public support and public funding would create opportunity for additional private spending (EC 2003).

2.2 Review, refocus and improvement of instruments, 2004-2005

In 2004, a High Level Group was established at the request of the Brussels Council to make an independent mid-term assessment of progress on the Lisbon strategy. The group, chaired by former Dutch Prime Minister Wim Kok, found insufficiencies in both investment in R&D and absorptive capacity, i.e., the ability to share knowledge and to turn research into commercial products and services (EC 2004). Only two member states exceeded the 3% R&D objective at that time, and the Union-wide average was about 1.9%.

The situation was compounded by enlargement of the EU, which increased its population by 20% but improved GDP by only 5% (EC 2004, 13). Kok's report cited many of the same obstacles referred to in earlier EU documents, and it made specific recommendations, including an action plan to attract researchers and establishment of the European Research Council (ERC) to fund basic

research. It also called for better integration of instruments, such as financial markets and regulatory climates. Additionally, the report recommended national action programmes² to be put in place by the end of 2005 and a public listing of member states' progress on the various measures and indicators. These national plans represented a clear attempt to clarify the responsibilities of the individual member states.

As a result of this review, EU President José Manuel Barroso presented a communication document (EC 2005b) to the 2005 Spring European Council, proposing a two-part parsing of the Lisbon strategy to be refocused specifically and solely on growth and jobs. This, in effect, removed some of the broader components of the original Lisbon goals and distilled the strategy down to one of technology and economics only. Again, an increase in investment in both public and private R&D was encouraged. Member states were asked to thoroughly explain their action plans for working toward the 3% R&D spending target. A coordinated approach to tax incentives, particularly for small and medium-sized enterprises (SMEs), was specified as a key success factor, along with reform of the State Aid Framework to make financing more accessible (22). The need to establish innovation poles for strengthening regions was echoed, emphasizing public-private cooperation, and establishment of the European Institute of Technology (EIT)³ was proposed (23).

After achieving full support of the European Council, the European Commission followed up these recommendations with the Community Lisbon Programme, a series of action items for implementation on the community level in coordination with the previously proposed member states' national action programmes⁴ (EC 2005a). This plan provided a summary of many of the instruments already suggested and more clearly delineated the responsibilities of the Commission and the individual member states, as illustrated in Figure 2.1.

Figure 2.1: Community Lisbon Programme action items for putting research and innovation at the heart of EU policies

Putting research and innovation at the heart of EU policies:		
	Commission's responsibility	Member states' responsibility
1	Step up dialog with stakeholders to identify regulatory barriers	Transpose EU legislation in order to promote research and innovation
2	Reform state aid regime to be more friendly for research and innovation	Fully exploit opportunities in the reformed framework to support research and innovation
3	Support actions to improve intellectual property rights system and its use	Adopt a community-wide patent system and meanwhile improve current system
4	Support, monitor and further develop strategy for human resources in research sector	Implement any directives as adopted for research human resources
5	Promote use of public procurement to stimulate research and innovation	Review procurement practices through mutual learning and exploit new possibilities
6	Provide guidance to promote optimal use of tax incentives for R&D	Voluntarily implement guidance for tax incentives within national context

Source: Adapted from European Commission 2005a, pp.5-10.

In addition, the plan earmarked structural and cohesion funds to increase R&D and innovation capacity, and the Commission created new instruments in the Seventh Framework Programme (FP7)⁵ for research, technological development and demonstration activities, such as the Risk-Sharing Finance Facility (RSFF) to improve access to European Investment Bank (EIB) financing

² When referring to specific European initiatives, the word "program" is spelled herein in British English, i.e., "programme", in keeping with official European Union names and publications.

³ The EIT was approved in July 2007 with a new name, European Institute of Innovation and Technology, reflecting the importance of innovation to the institution.

⁴ These national action programmes are alternatively referred to as national reform programmes and sometimes abbreviated as NFPs in EU documents.

⁵ The Framework Programme began in 1984 as an umbrella for research funding activities performed by the European Union. The Seventh Framework Programme covers the funding period from 2007 to 2013.

(EC 2005a,11). Some of these additional measures for funding and business are detailed in Figure 2.2. The member states received planning assistance in the form of integrated guidelines, thus providing a structure to create plans that would be at once both customized and easily comparable.

Figure 2.2: Community Lisbon Programme action items for putting research and innovation at the heart of EU funding and business

Putting research and innovation at the heart of EU funding & business:		
	Commission's responsibility	Member states' responsibility
1	Use Structural Funds to drive research and innovation	Adopt proposals for Cohesion and Structural Funds and exploit new opportunities
2	Promote better access to financing for SMEs	Make use of equity and guarantee schemes and engage financial community
3	Support development of new technologies and market uptake	Adopt proposals for FP7 and Competitiveness and Innovation Framework Programme
4	Mobilize national and regional programs	Take full advantage of EU's schemes for transnational cooperation
5	Define guidelines for public-private collaboration and knowledge transfer	Implement the guidelines within national context
6	Promote innovation poles and clusters	Use Structural Funds to develop innovation poles and clusters
7	Provide business support , especially for SMEs	Use Structural Funds to improve innovation support
8	Promote good innovation management practices	Promote use of tools and consider rewards
9	Expand monitoring and analysis for private spending and sectoral performance	Take account of results of EU monitoring and analysis

Source: Adapted from European Commission 2005a, pp. 10-19.

2.3 Targeting ongoing barriers from 2006

Once again, the European Commission appointed an expert group to review progress prior to the 2006 Spring European Council. The group, chaired by former Finnish Prime Minister Esko Aho, found a gap between rhetoric and achievement, and thus distilled the group's findings down to three specific barriers and made recommendations for each (EC 2006). The first barrier is *lack of an innovation-friendly environment*. Their report suggested coordinating demand through public procurement and continuing to make progress on policies and regulations. The second barrier is the *lack of sufficient resources*. Again, a better use of instruments, state aid reform and public-private collaboration were recommended to address this problem. Additionally, the report suggested looking more carefully at philanthropic organizations as a source of funding – thus far an underutilized tool in Europe (15). Lastly, the third barrier is *mobility*, and the report includes people, financing and knowledge here. Suggestions were based on eschewing the status quo: looking beyond existing clusters⁶ and industrial sectors, removing barriers for older workers and those with families, and improving conditions for venture capital (VC) and private equity (PE).

To underscore this last point, the report cites a 40% increase in VC and PE-supported firms between 1995 and 2006, concluding that such firms are six times as R&D-intensive per employee as the average of the top 500 R&D spenders in the EU25⁷ and that they created 630,000 new jobs

⁶ Clusters refer to the concept model developed and diffused by Michael Porter in which related companies and institutions within a geographical area interact to share knowledge, increase productivity and encourage innovation and growth for competitive advantage.

⁷ EU25 are the member states of the European Union in 2006 prior to accession of Bulgaria and Romania in 2007, which brought the number to its current total of 27.

between 2000 and 2004 (EC 2006, 20). But high start-up costs and fewer business angels in Europe result in average VC investments per company of only one sixth those in the US. Strengthening of the European Investment Fund (EIF), run by the European Union to support SMEs, was recommended in order to maintain funding during slower economic cycles and to prevent an excessive boom in technology following recovery (EC 2006, 21).

In 2007, the European Commission specifically addressed knowledge transfer between research institutions and industry in order to make better use of public funds for R&D, again placing the need for improved mobility front and center (EC 2007c). The report stressed the importance of highly skilled personnel possessing a wide range of skills to ensure knowledge transfer, along with the need for movement or loans of people between the public and private sectors (4, 6). It then proceeded to review a number of existing and previously proposed instruments that could be used to encourage links between organizations. The proposal for the EIT was offered as an example of innovative governance, employing both bottom-up and top-down approaches through its 'knowledge and innovation communities' and its governing board, respectively. The former will foster joint public-private ventures (8).

While the EU has remained relatively non-interventionist in favor of market forces, a common commercial policy, competition policy and standards for the internal market represent coordinated actions (Molle 1997). Other relevant activities include the Committee for Scientific and Technical Research (CREST), created to encourage information and best practice exchange, a new framework for state aid, which clarifies the rules for subsidies, and the use of structural funds, including the European Regional Development Fund (ERDF), which supports incubators and science parks in moving knowledge from public institutions to industry, and the European Social Fund (ESF), which provides assistance and training to individuals.

These recommendations characterize the development and redesign of research and innovation policy action for the EU in recent years. Efforts to address global challenges have clearly shifted to a new focus on innovation economics, following an increasingly active view to technology policy in previous decades. While it is out of the scope of this paper to present an historical background for such policy development in the EU, Appendix A contains an overview of selected past and current EU programs and actions relative to research and innovation. More to the point is putting this challenge into perspective by looking at key figures leading up to and since the establishment of the Lisbon agenda.

3 Measuring the global challenge for Europe

3.1 Monitoring and assessment

To measure progress on its Lisbon strategy, the Council set a requirement for annual spring reports from the European Commission covering six main categories: general economic background; employment; innovation and research; economic reform; social cohesion; and the environment (Casey & Collins 2004, 20-21). The Lisbon indicators are structural in nature; that is, they tend toward longer-term indices and are used to shape policies that may take a number of years to implement and demonstrate clear results (EFTA 2007). Because they are rather broad, it is difficult to correlate their use directly to the effects of any specific actions (Casey & Collins 2004, 21).

By 2007, over 128 different indicators had been identified among the categories. In 2004, the Commission defined a short list of 14 indicators, organized in structural categories as shown in Figure 3.1. In that same year, as part of a larger study funded through the Sixth Framework Programme (FP6), Technopolis used these Lisbon objectives to test the efficacy of the Monitoring and Impact Performance Indicators, in which the EU sought to study its overall strategy for monitoring progress throughout FP6 (Casey & Collins 2004). The study concluded that the short-list indicators are credible, easy to operate and are sufficiently flexible and open to further development; however, it cautioned that they speak only to common aims and do not necessarily address specific objectives (36).

Figure 3.1: Short list of Lisbon indicators by category

Category	Indicator	
General economic	1	GDP per capita in PPS
	2	Labor productivity
Employment & education	3	Employment rate
	4	Employment rate of older workers
	5	Educational attainment (20-24 year old age group)
R&D	6	Research & development expenditures
Economic growth/reform	7	Comparative price levels
	8	Business investment in capital
Social cohesion	9	At-risk-of-poverty rate
	10	Long-term unemployment rate
	11	Dispersion of regional unemployment rates
Environment	12	Greenhouse gas emissions
	13	Energy intensity of the economy
Transport	14	Volume of freight transport

Source: Adapted from EFTA 2007, Sulmicka 2005, Casey & Collins 2004.

Although all of the indicators taken together provide a fuller picture of the conditions for economic development, only one indicator on the short list, R&D expenditures (as highlighted in figure), relates specifically to innovation and research. In practice, this translates to comparison not only of absolute spending but also more typically to comparison of R&D spending relative to GDP.

There is a rather clear historical basis for the use of R&D expenditures as a percentage of GDP as a measure of innovation and growth. The US National Science Foundation (NSF) adopted this indicator, followed in the 1950s and 1960s by other member countries of the Organisation for Economic Cooperation and Development (OECD). In 1963, the Frascati Manual⁸ defined and standardized its use, cautioning that R&D performance alone was not sufficient to gauge the overall potential for change (Freeman & Soete 1997, 300).

It is important to observe that R&D spending is an input of research and innovation, rather than an output produced by activity, such as the number of patents or frequency of scientific publications (Kroll & Stahlecker 2005, 12). As such, it is a measure of potential, especially given that potential output and subsequent likelihood of commercialization are neither guaranteed nor necessarily predictable (Smith 2000). That said, however, the measure of R&D spending against GDP remains the most accepted indicator for comparison among actors and over time.

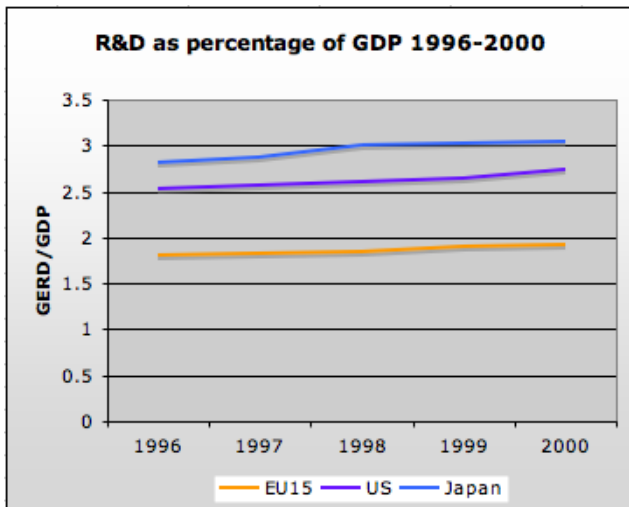
3.2 Key figures for research and development

At the beginning of the new millennium, the European Union lagged behind the US and Japan in R&D spending, and the gap appeared to be widening. A look at conditions in the five years between 1996 and 2000 provides insight into the challenge that the EU was facing at that time.

In 2000, the US invested over 120 billion Euros more than the EU15 in R&D, and the percentage of GDP used for gross expenditures on R&D (GERD) was on the rise in the US, measuring about 2.7%, while it was stagnant in Europe at about 1.9% (EC 2002, 3-4). Figure 3.2 clearly shows the worrying trend as it appeared in 2000.

⁸ The Frascati Manual is a publication of the OECD that standardizes the methodology for collecting and applying R&D statistics.

Figure 3.2: Gross R&D expenditures as a percentage of GDP in selected areas from 1996 to 2000



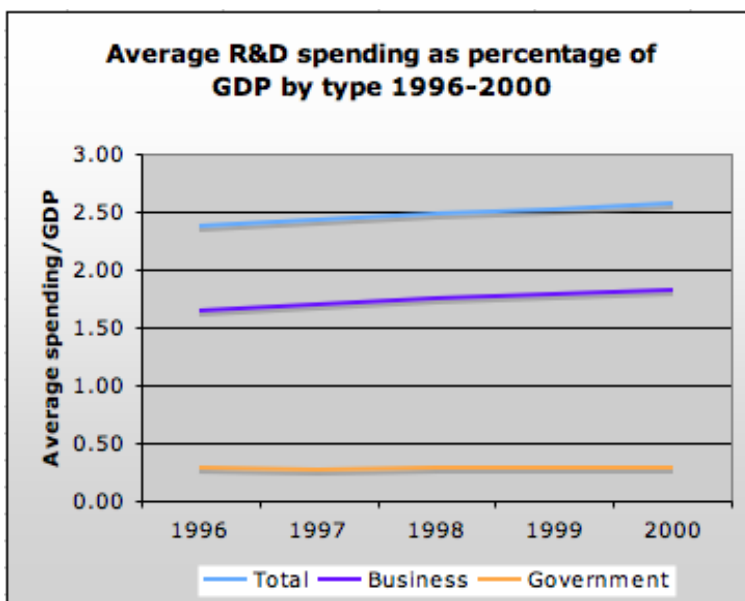
Source: Fraunhofer ISI regional key figures database; adapted from DG Research 2003, p. 13.

While all three zones exhibited moderate growth in the ratio between 1996 and 2000, Japan continued to dominate, and both the US and Japan recorded stronger improvement than the EU15. But more to the point, both countries were clearly ahead of the EU15 in spending relative to GDP, and the gap in performance was worsening.

In that same year, the European Commission found that at least 80% of the gap between the US and Europe could be attributed to lower R&D investment by industry (EC 2002, 6). This is confirmed in Figure 3.3, in which spending intensity in all three zones is averaged together.

When averaged together, the total combined R&D expenditures as a percent of GDP in the EU15, US and Japan increased rather consistently with average business expenditures on R&D (BERD) as a percentage of GDP between 1996 and 2000, while average government expenditures on R&D (GOVERD) as a percentage of GDP in the three zones remained flat. This shows that, on the whole, increased participation by industry in R&D spending accounted for the overall increase in the ratio.

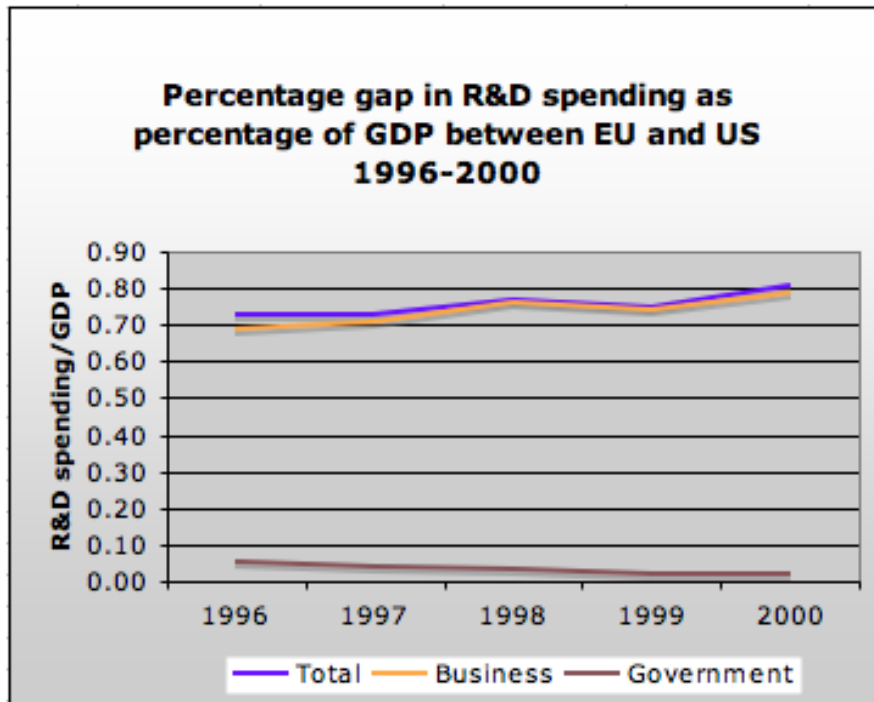
Figure 3.3: Combined average gross R&D spending as a percentage of GDP in the EU15, US and Japan between 1996 and 2000 by total, business and government expenditures



Source: Fraunhofer ISI regional key figures database.

The actual gap in percentage points between the intensities of the US and EU15 during the same time period, displayed in Figure 3.4, shows that the difference in government sector R&D was rather small and slowly closing as the gap in business sector R&D was worsening, closely following the overall trend in total expenditures. This finding indicates that R&D expenditures by industry do in fact account for the increasing gap and suggests that policymaking efforts should be targeted at encouraging additional business expenditures in Europe, although it offers no assumptions as to the most effective way for government to stimulate such spending.

Figure 3.4: Percentage gap in gross R&D spending as a percentage of GDP between the EU15 and the US from 1996 to 2000 by total, business sector and government spending



Source: Fraunhofer ISI regional key figures database; adapted from DG Research 2003, p. 14.

In order to increase R&D spending relative to the proposed Lisbon objective of 3% of GDP overall with two thirds coming from industry, significant leaps in the annual rate of growth were required. Figure 3.5 shows growth at a 2000 baseline, along with the increases necessary to achieve the goal in combination with estimated GDP growth rates ranging from 0-3%.

With absolutely no change in GDP, the annual rate of growth in R&D spending (GERD) would have had to increase from a 1990s average of 2% to an ongoing rate of nearly 4.8% over the decade; and in order to keep up with historical GDP growth of about 2%, the annual rate of growth would have had to hit about 7%. The necessary increases are even higher for industry financed R&D, which would have had to increase by nearly 7% per year with no additional GDP growth and by nearly 9% per year with an historical GDP growth rate of 2% (DG Research 2003, 19). Sulmicka (2005) reported that the average annual growth rate of the R&D share of GDP is actually only about 3%, which proves too slow to achieve the 3% objective by 2010 (14).

Figure 3.5: Making the proposed targets for R&D spending in the EU with estimated GDP growth rates ranging from 0-3%

Making the proposed targets for R&D spending in the EU					
	Baseline (2000 and trend from 1990-2000)	Estimate in 2010 value			
		Percentage annual growth in GDP			
		0	1	2	3
GDP (million €)	8,169,287	8,169,287	9,023,975	9,958,315	10,978,839
GERD (million €)	153,885	245,079	270,719	298,749	329,365
GERD/GDP (%)	1.88%	3.00%	3.00%	3.00%	3.00%
Growth GERD (million €)	28,660	91,194	116,834	144,864	175,480
Annual growth GERD (%)	1.99%	4.76%	5.81%	6.86%	7.91%
Industry financed GERD (million €)	85,369	163,386	180,480	199,166	219,577
Industry financed GERD/GDP (%)	1.04%	2.00%	2.00%	2.00%	2.00%
Growth Industry financed GERD (million €)	22,914	78,017	95,111	113,797	134,208
Annual growth industry financed GERD (%)	2.75%	6.71%	7.77%	8.84%	9.91%

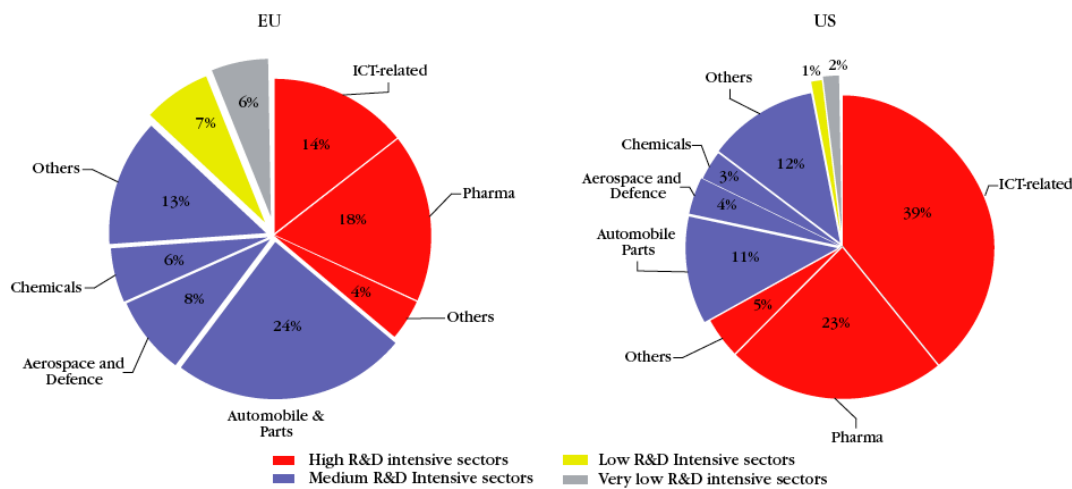
Source: DG Research 2003, p. 20, based on OECD figures.

Note: Targets as highlighted – 3% for GERD/GDP, of which 2/3rds is industry financed.

The gap in R&D investment by EU firms in the US versus US firms in Europe increased by about 500% between 1997 and 2002 (EC 2006, 2). In 2004, the Wim Kok review, among others, blamed the lack of progress on a number of macroeconomic conditions, including the recession, falling world stock values, appreciation of the Euro and bursting of the dot-com bubble in the US, which translated to poor growth and shortfalls in completing the single market in Europe (Sulmicka 2005, 9; EC 2004, 9-10). The same review stated that 74% of the world's top 300 IT companies and 46% of the world's top 300 R&D-producing firms came from the US in that year (EC 2004, 12).

Such results seriously call into question the achievability of the Lisbon goal for R&D; however, Key Figures 2007, an annual publication from the Directorate-General for Research, (DG Research) claims, "If the Member States reach their objectives, the overall EU R&D intensity will have increased substantially to about 2.6% in 2010" (DG Research 2007a, 8). While the report goes on to concur that the business expenditure gap between the US and Europe has continued to widen since 2000, it also demonstrates that the US dominates only in higher technology industries. Interestingly, differences are minimal at the individual sector levels when comparing relative performance; therefore, the gap is attributed to the *structure* of these sectors within the larger industrial mix (DG Research 2007a, 31, 35; O'Sullivan 2007, 10). This is illustrated in Figure 3.6, which reveals that sectors that are highly R&D intensive, including information and communication technology (ICT) and pharma, account for 67% of industry in the US and only 36% in the EU.

Figure 3.6: EU and US industry by sector and R&D intensity



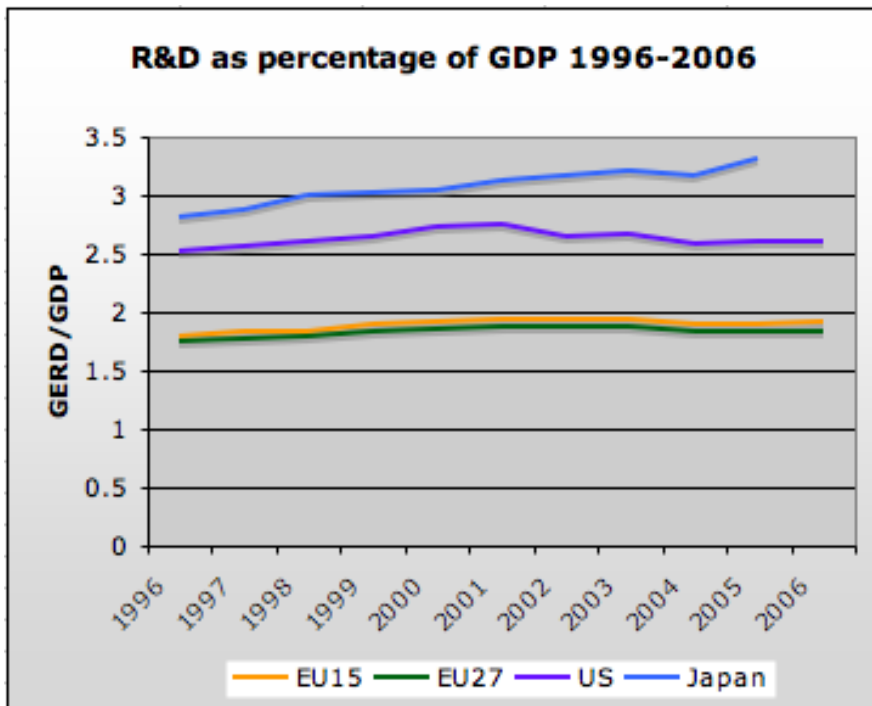
Source: DG Research 2007a, p. 31.

The key figures review concluded that faster reforms to stimulate business R&D spending are necessary, particularly in financing new firms and new sectors and in improving knowledge and technology transfer. As an example, it is instructive to note that US patents use less knowledge generated in the EU than EU patents' use of knowledge generated in the US; this, coupled with the fact that US inventors also use a much larger share of homegrown knowledge, shows a large disproportion in knowledge flows within and between the two zones (DG Research 2007a, 50).

The most recent figures for GERD as a percentage of GDP remain disappointing for the EU. Figure 3.7 extends the timeline to 2006 and shows performances for both the EU15 and the current EU27 since 1996 against results for the US and Japan. Japan's spending ratio continues to rise, and though the US has lost some ground, due at least in part to post-2001 economic conditions, the ratio remains above 2.5%, while the EU continues to struggle below the 2% mark. Meanwhile, other countries are making fast progress, such as China, India, and the Republic of Korea – where R&D spending is expected to reach 5% of GDP by 2012 (Korea.net 2008).⁹ And while the EU's GDP growth rate over the same period has also remained disappointingly below 2% per year, the US has managed about 3% per year and the Asian countries have continued to explode with growth as high as 7% in Korea and annual rates above 10% in China through last year (Aghion & Durlauf 2007).

⁹ According to Oh and Heshmati (2005), the Republic of Korea has committed to using technology-based innovation as its prime source of economic growth in hopes of achieving G7 development levels as quickly as possible. An excellent discussion of the key factors influencing that country's formidable economic growth and increase in R&D intensity is found in their paper, pp. 14-16.

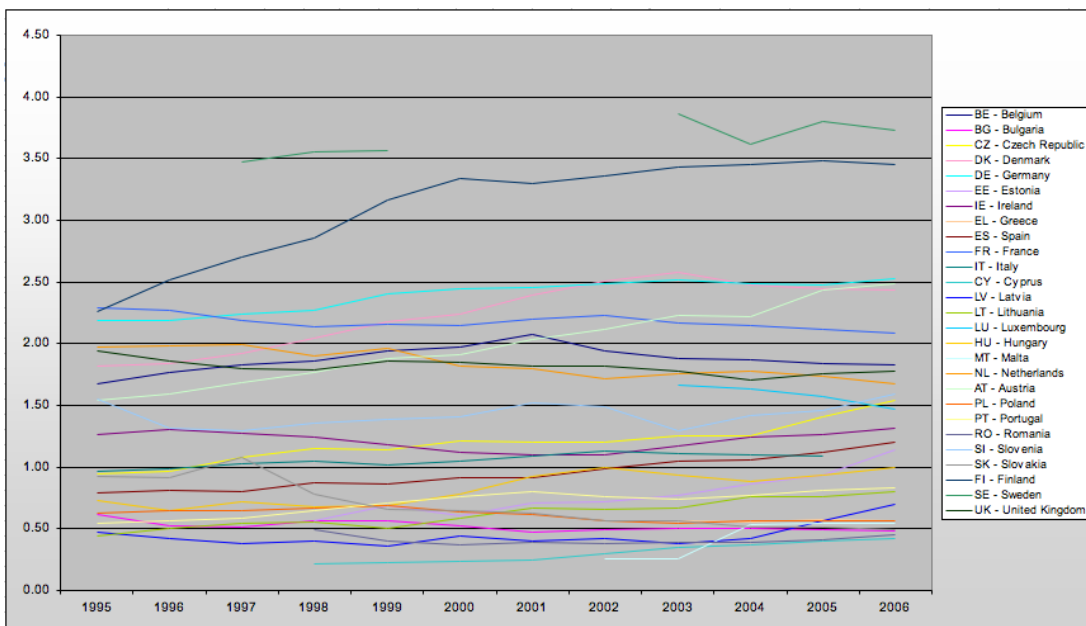
Figure 3.7: Gross R&D expenditures as a percentage of GDP in selected areas from 1996 to 2006



Source: Fraunhofer ISI regional key figures database.

Results at the EU level do little to reveal R&D performance by the individual member states. Country-by-country analysis of the nations forming the EU provides a mixed picture. As may be expected, there are a number of political and socio-economic factors offered to explain the wide variances in intensity between countries. These include not only absolute spending on R&D but also the level of technological readiness and capacity for absorption, frameworks for public-private cooperation, and the skill and availability of scientists and engineers (Blanke 2006, 7, 17). The development of intensities by country is displayed in Figure 3.8.

Figure 3.8: Gross R&D as a percentage of GDP in EU member states from 1995 to 2006



Source: Fraunhofer ISI regional key figures database.

Note: Some data points are not available and several 2006 results are based on estimates.

Of particular note are the limited number of member states above the 2% mark and the majority at or below 1.5%. In an effort to understand the possible causes for these differences, an excellent Lisbon review is published bi-annually by the World Economic Forum. Using a slightly different category breakdown, albeit quite similar to that employed by the European Commission, this organization uses both hard data and surveys of business leaders to gauge progress on the main factors influencing the Lisbon strategy objectives. The categories analyzed are: information society for all; innovation and R&D; liberalization; network industries; financial services; enterprise environment; social inclusion; and sustainable development. Results from a number of sub-category weightings are compiled on a rating scale of 1 to 7 (with 7 representing the highest score) for each of the individual EU25 countries and compared to the EU25 as a whole, the US benchmark and East Asia (Blanke 2006). Figure 3.9 presents findings from the latest available report, the Lisbon Review 2006, the third edition of this publication. Individual country scores that exceed the US benchmark score in the respective categories and in the final index are highlighted, and the high score in each index is rendered in bold type.

Figure 3.9 Lisbon Review 2006 ranking and scores of 25 individual EU countries, the EU25, US and East Asia by final index and sub-index categories

Country	Final Index				Sub-indices															
	2006	2004	Move	Score	Information Society		Innovation and R&D		Liberalization		Network Industries		Financial Services		Enterprise		Social Inclusion		Sustainable Development	
					Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score
EU 25																				
Denmark	1	2	+1	5.76	4	5.53	4	5.15	5	5.58	2	6.24	5	6.28	1	5.63	1	5.49	3	6.17
Finland	2	1	-1	5.74	6	5.41	1	5.90	4	5.58	8	5.93	4	6.29	4	5.24	2	5.35	1	6.23
Sweden	3	3	--	5.74	1	5.93	2	5.73	6	5.43	5	6.14	3	6.36	7	5.07	3	5.09	4	6.15
Netherlands	4	5	1	5.59	2	5.63	5	4.82	2	5.62	6	6.01	6	6.23	2	5.48	4	5.06	6	5.87
Germany	5	6	1	5.53	10	4.98	3	5.31	1	5.71	1	6.38	2	6.39	12	4.69	10	4.53	2	6.23
United Kingdom	6	4	-2	5.50	3	5.61	6	4.82	3	5.59	7	5.97	1	6.47	5	5.13	9	4.74	8	5.69
Austria	7	9	2	5.30	7	5.24	9	4.55	7	5.35	9	5.87	8	6.15	15	4.43	8	4.75	5	6.09
Luxembourg	8	7	-1	5.29	9	5.05	12	3.96	9	5.26	4	6.16	9	6.14	8	4.91	5	5.05	7	5.82
France	9	8	-1	5.21	11	4.91	8	4.66	11	5.17	3	6.18	7	6.19	9	4.87	15	4.25	10	5.44
Belgium	10	10	--	5.15	14	4.44	7	4.67	10	5.25	10	5.84	11	5.91	11	4.77	6	4.83	9	5.47
Ireland	11	11	--	5.09	12	4.55	10	4.47	8	5.34	18	4.95	10	6.13	3	5.35	7	4.82	11	5.10
Estonia	12	12	--	4.93	5	5.49	11	4.06	12	4.98	17	5.01	12	5.72	6	5.10	12	4.37	16	4.69
Portugal	13	17	4	4.64	17	4.06	17	3.91	15	4.74	12	5.37	13	5.66	14	4.50	17	4.10	14	4.90
Czech Republic	14	19	5	4.53	15	4.10	16	3.85	13	4.96	13	5.16	21	4.84	21	3.99	11	4.44	13	4.90
Spain	15	13	-2	4.49	20	3.93	15	3.89	16	4.62	11	5.41	14	5.65	16	4.33	23	3.63	18	4.48
Slovenia	16	15	-1	4.44	13	4.50	13	3.96	22	4.30	15	5.07	20	4.88	23	3.76	19	4.02	12	5.00
Hungary	17	20	3	4.40	23	3.74	14	3.92	17	4.55	21	4.80	17	5.22	19	4.18	16	4.16	17	4.61
Slovakia	18	23	5	4.38	19	3.97	23	3.44	14	4.82	22	4.76	22	4.84	17	4.33	18	4.09	15	4.76
Malta	19	18	-1	4.38	8	5.22	25	3.23	19	4.46	23	4.64	15	5.44	22	3.83	13	4.35	25	3.84
Lithuania	20	21	1	4.31	18	3.97	20	3.69	24	4.18	19	4.86	19	4.96	13	4.57	20	3.95	21	4.26
Cyprus	21		--	4.28	21	3.90	24	3.30	18	4.46	16	5.02	18	5.12	18	4.25	14	4.30	24	3.86
Latvia	22	16	-6	4.25	22	3.76	21	3.63	20	4.32	24	4.57	24	4.79	10	4.78	21	3.87	20	4.29
Greece	23	22	-1	4.19	25	3.17	18	3.77	21	4.32	14	5.09	16	5.27	20	4.14	22	3.79	23	3.98
Italy	24	14	-10	4.17	16	4.06	19	3.73	23	4.29	20	4.82	23	4.80	24	3.71	24	3.54	19	4.40
Poland	25	24	-1	3.76	24	3.32	22	3.57	25	4.02	25	3.86	25	4.23	25	3.60	25	3.41	22	4.10
EU25 Average	--	--	--	4.84	--	4.58	--	4.24	--	4.92	--	5.36	--	5.60	--	4.59	--	4.40	--	5.05
United States	--	--	--	5.45	--	5.63	--	6.01	--	5.21	--	5.72	--	5.97	--	5.21	--	4.58	--	5.26
East Asia*	--	--	--	5.28	--	5.41	--	5.23	--	5.13	--	5.96	--	5.54	--	5.11	--	4.87	--	5.02

* East Asia refers to the average of five competitive East Asian economies: Japan, Hong Kong, Republic of Korea, Taiwan and Singapore

 = score for individual country outperforms score for US benchmark

Source: Blanke 2006, pp. 5-6.

Particularly striking is that the US outperforms the EU25 average in all categories despite a few higher individual scores in several northern EU countries, and not a single EU country scores as high in innovation and R&D. The Scandinavian countries continue to show the strongest performance, based on solid across-the-board scores, while southern Europe and the newer EU countries tend to display weaker performance; however, several of these member states show strong positive movement, including Portugal (for improvements in the enterprise environment), Czech Republic, Hungary and Slovakia (Blanke 2006, 5-6). These countries appear to be experiencing catch-up tendencies, growing quickly from very low levels and benefiting from spillover of knowledge from other regions, which results in higher relative growth rates (Aghion & Durlauf 2007, 6; Kroll & Stahlecker 2005, 14). Besides low R&D spending, the poorest performing countries continue to be challenged by bureaucracy, government favoritism and a lack of new technologies, competitive local markets and protection of property rights (Blanke 2006, 7).

For another visual representation of these results, Appendix B provides user-friendly comparative radar diagrams from the Lisbon Review 2006 for each country in the EU25, along with a more detailed description of the sub-index ranking categories.

3.3 The regional dimension

This demonstrated country diversity is at the heart of the aforementioned Lisbon national action programmes, in which individual targets and priorities are set based on national specificities. But in nearly all cases, these differences go beyond the country level, reaching deep into regions centered on or near capital cities or in other important urban/industrial areas. The national level provides a foundation for regional policies, and there is support for regionalization at the EU level. The European Commission has stated, "From a competitiveness and cohesion point of view, there is thus a clear need to formulate integrated RTD and innovation strategies which connect to the economic development process in the regions and which, via the national system of RTD and innovation support, is integrated into a wider European perspective" (EC 1998, 9).¹⁰ This support is evidenced by the use of tools, such as the Framework Programme and structural funds.

Clearly, the proximity of R&D actors is a compelling reason for the increasing importance of regions. These actors are both private and public, including industry, universities and public research institutions, and include knowledge creators and knowledge users (DG Research 2003). The creation of partnerships, and in particular of industry clusters, coupled with common cultural norms, influences the transferability of knowledge and the absorptive capabilities in the regions.

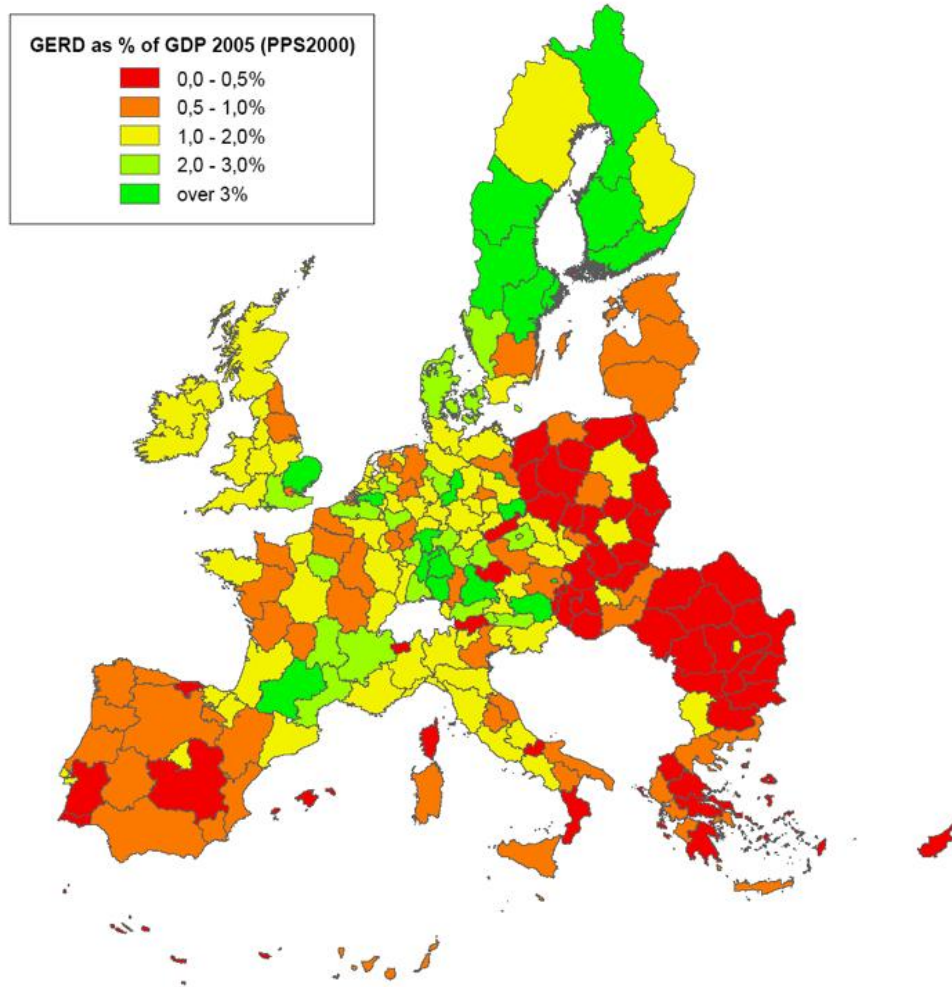
The EU uses a standard referencing system, the nomenclature of territorial units for statistics, or NUTS, to identify and differentiate the regions.¹¹ The national level is sometimes referred to as NUTS0, and there may be as many as five classifications below the country level. Most of the relevant regions for R&D are at the NUTS2 level, of which there are 268 in the EU27. Of these, over 100 regions currently measure R&D intensities below 1%, with just 8 regions representing 25% of R&D investment and 31 regions accounting for 50% (Myllyvirta 2008). Figure 3.10 shows how R&D intensities vary greatly on the NUTS2 level.

Despite a number of strong regions, it is apparent that the majority of regions does not perform to target and likely cannot do so. The European Commission's 3% objective is a Union-wide goal, and with an aggregate level of just below 2%, it is clear that the higher performing regions are already making up for poor intensities in other regions; however, the call to increase opportunities for achieving the intended levels and speeds of growth necessitates particular attention to the needs and specificities of all individual regions and the role of the public sector.

¹⁰ RTD here means research and technological development and is a broader and more commonly used abbreviation than R&D in many EU publications.

¹¹ NUTS comes from the French, nomenclature d'unités territoriales statistiques. Generally, NUTS0 is the country level, NUTS1 is a state or collection of states and NUTS2 is the regional level; however, this depends on country size as each level has minimum and maximum population thresholds such that countries do not all break down to the same levels. More information is available from Eurostat at the following URL:
http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1335,72265683,1335_72320391&_dad=portal&_schema=PORTAL#principles.

Figure 3.10: 2005 gross R&D intensities in EU NUTS2 regions (measured in PPS2000)



Source: Fraunhofer ISI regional key figures database.

4 Regional theory and the role of the public sector

4.1 Sectoral composition and regional agglomeration

Regional performance cannot be understood without an eye to sectoral composition. The European Commission's Independent Expert Group found that business R&D spending accounts for most of the gap in intensity between the EU and the US, where in the latter spending is dominated by ICT and services (O'Sullivan 2007; DG Research 2003). As noted, while overall performance in individual sectors is relatively comparable between the EU and the US, the sheer size of the high tech sector in the US represents an advantage. Sulmicka (2005) found that uptake of ICT is hindered in Europe by absolute underinvestment in the sector and by slow progress in management and training, leading to 50% lower input in the growth of labor productivity in the EU15 (14).

There is clearly a regional dimension in bridging initiatives between the private and public sectors and between knowledge users and creators. But many regions in Europe focus on industries such as tourism, fashion, or finance and other services, and here interpretations of R&D as a percentage of GDP do not account for these specializations in which high R&D may not correlate to growth potential (van Pottelsberghe 2008). This tendency for specialization, van Pottelsberghe posits, explains more variances than country specifics. He explains that although the same regional variances in performance exist in the US, the overall intensity remains higher because the US benefits from its size, homogeneity, common language and convergent regulations (6).

In its 2007 green paper on the ERA, the European Commission addressed this issue by turning its attention to infrastructure, worker mobility and clustering. While continuing to support reforms at the national level, the green paper argues that voluntary compliance from member states results in slow progress (EC 2007b, 13). The European Commission followed this paper with a working document that specifically speaks to cross-border spillover and complementarities, suggesting that national action alone would not exploit economic opportunities (EC 2007a, 3). In the short run, trading partners would gain from an increase in demand; however, this gain could be lost in the long run as competition increases, causing prices and wage drops to reverse the trend (4). But LERU (2007) cautions against jumping to mistaken assumptions that networks should be formalized and coordination should be centralized, which could inhibit bottom-up measures (3-4). While agreeing that coordination is required to monitor activities in the entire ERA, they propose that specialization calls for regional efforts that address regional priorities (4, 9).

Innovative regions benefit from a multiplier effect by which the region attracts highly skilled workers, and the concentration of talent attracts additional and often similar types of firms – a process known as agglomeration. Arthur (1989) showed that agglomeration in a model with unbounded returns results in an "historical accident" that leads to monopolization of an industry (243).¹² This can be seen quite clearly in Silicon Valley in the US, where mobility is high. But according to LERU (2007), "The primary attractor for individuals is not [simply] mobility but opportunity" (12). In Arthur's (1989) bounded model, agglomeration still occurs but can exist in multiple dominant locations at a similar rate as ceilings are met (246). Agglomeration helps to explain why specializations typically exist in geographical clusters, even in today's highly virtual world.

Nevertheless, Koschatzky (2005) explains that regional differences are not explained by locational factors alone; the capacity of actors within a region to form cooperative networks is decisive. Culture and identity affect actors in ways that can either support or hinder change, and when the latter occurs, socio-economic lock-in effects may result. In a supportive environment, a collective learning process develops that influences the absorptive capacity and level of knowledge sharing inherent in the region (294).

The role of the public sector is critical as governance actions can encourage openness, flexibility and ultimately competitiveness (Koschatzky 2005, 295). As discussed, a primary aim of the Lisbon strategy is to increase public R&D support to about one third of overall R&D spending in order to provide incentives for increased private investment. Appropriate measures, and thus policymaking, are dependent upon an analysis of the effect of public support on performance and the potential effects of targeted measures.

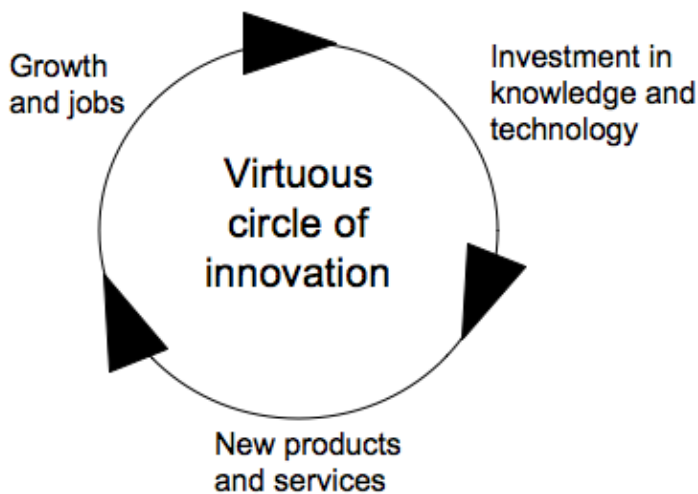
¹² Arthur's (1989) historical accident assumes that the early entry sequence of firm types occurs randomly based on locational taste, and different choices could sway results.

4.2 Market failure approach

4.2.1 Theoretical background for market failure

In early documents, the European Commission spoke of a "virtuous circle" of innovation (EC 2002, 5), which is pictured in Figure 4.1. The supposition is clear: investment in knowledge and technology should lead to new products and services, which in turn should stimulate competitiveness and employment, which should thus create incentives for more new investments. Policies, they suggest, are necessary to support the cycle, but they also warn that such policies must address the differences in the structure and sectors found in different regions – a type of differentiated coordination. This laid the foundation for applying the open method of coordination utilized in the national action programmes; that is, individual member states were given the mandate to set policy as best befits their own regional idiosyncrasies while tracking progress in a coordinated fashion.

Figure 4.1: Virtuous circle of innovation



Source: Adapted from EC 2002, p. 5.

A year later, in its action plan (EC 2003, 19), the Commission raised the possibility that public support could create distortion of competition, constituting state aid. To address this problem, revision was recommended that would allow state aid to be used for R&D by redefining eligibility and encouraging industry cooperation with research institutions. The real challenge, according to Aghion *et al.* (2007), is converting the virtuous circle into a virtuous spiral of growth by averting potential for such coordination failures (10).

Government intervention of any kind, classic macroeconomic theory tells us, is dependent upon and necessitates the existence of market failures (Aghion *et al.* 2007). Writing about the structure of invention in 1962, economist Kenneth Arrow wrote that information is asymmetric, and therefore incentives for innovation may be inadequate and progress suboptimal (Winter 2006, 1103; Smith 2000, 84).¹³ In an open system, companies are thought to turn their attention only to maximizing profits, and the state intervenes with policy action to address the problems. This need for profitability to justify action is known as appropriability.

Within this framework, Aghion *et al.* (2007), among others, define R&D as a public good in which social benefit often outweighs private benefit, thus leaving companies less willing to invest and/or preferring to remain free riders in which they hope to benefit only from the actions of others, which may in turn result in insufficient action overall (5).

Additionally, R&D-producing companies are likely to fund their "best" projects¹⁴ first in order to maximize their private benefit, so the effectiveness of additional spending naturally decreases when moving down the project list and could even begin to show a marginal deficit as resources are used

¹³ Winter (2006) refers to Arrow, K.J. (1962) The rate and direction of inventive activity. In: Nelson, R. (Ed.) *Economic welfare and the allocation of resources for invention*. Princeton, NJ: Princeton University Press, pp. 609-625. Winter does not differentiate between the effect on invention or innovation.

¹⁴ Best projects are defined as those with the most profit potential and that require the least amount of additional hiring and/or training.

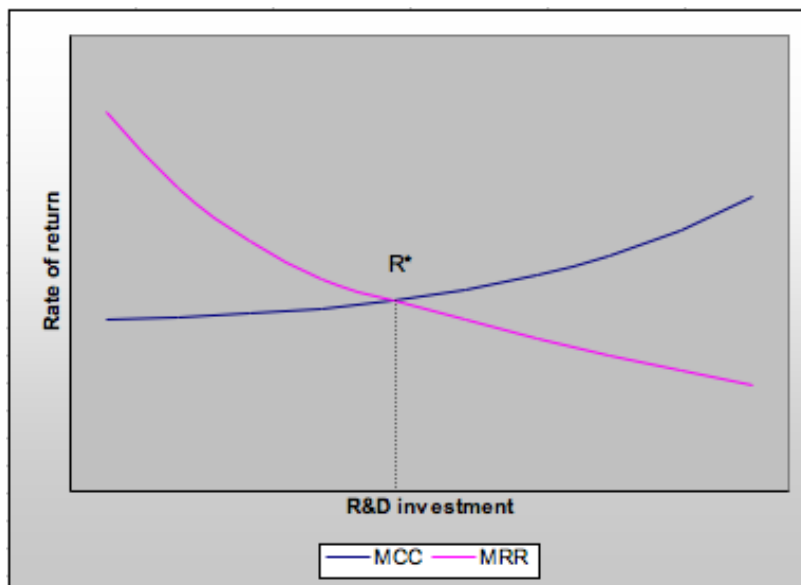
up (Gelauff & Lejour 2006, 79). Government support targeting winning projects could potentially serve to finance only projects that companies would have undertaken anyway, known as deadweight, constituting a crowding out effect on private spending.

4.2.2 Empirical evidence for market failure and connection to the Lisbon strategy

David *et al.* (1999) studied through ex-post inquiry the effect of public spending on private R&D in manufacturing, where the majority of the world's R&D expenditures occur. They looked in particular at subsidies (or grants), which are typically offered through an application process that favors projects with higher social benefits, and they suggested that such support could influence firms to reduce their own R&D spending. Since most previous analysis favored complementarity, the study sought to determine when substitution was more likely to occur.

To understand their approach, a microeconomic view is necessary. The optimal amount of a company's R&D spending is plotted by finding the equilibrium between the marginal rate of return (MRR) on investment, which slopes downwards as the company moves sequentially through its list of potential projects, and the marginal cost of capital (MCC), which increases as the company seeks funding above and beyond its own internal resources, as seen in Figure 4.2. External conditions that have an effect on MRR include technological opportunities and changes in demand. Those that affect MCC include the impact of policies, access to financing and macroeconomic conditions that alter project costs. This basic premise helps to illustrate the effect of grants on the schedules under certain conditions (David *et al.* 1999, 13).

Figure 4.2: Optimal R&D spending at R^* – schedules of marginal rate of return (MRR) and marginal cost of capital (MCC)



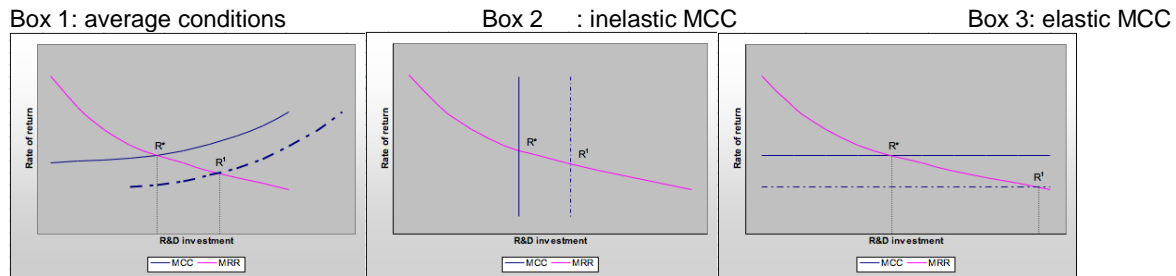
Source: Adapted from David *et al.* 1999.

First, a grant normally shifts the MCC curve to the right, as additional financing is now necessary further down the list of projects. The effect of the grant on the company's investment, however, depends on the elasticity of the MCC. Under general circumstances, the cost of capital rises at a later point in the project list, so the company could choose to simply move down the list even if the incremental increase in spending is less than the amount of the grant. This is illustrated in box 1 of Figure 4.3. Of course, a company might not choose to fund additional projects on its own as is suggested. This may occur when grants target only deadweight, again areas in which a company would have already chosen to invest. In this case, the shape of the MRR curve changes, pushing down and to the left, and crowding out is the result (David *et al.* 1999, 14-17, 19-20).

Similarly where MCC is perfectly inelastic, i.e., the firm is asset constrained, the grant will increase the company's R&D performance only by the amount of the subsidy itself, leading to no additional spending as seen in box 2 of Figure 4.3. Where MCC is perfectly elastic, as in box 3, internal costs are lowered; the amount is dependent upon how far the MCC drops and on the slope of the MRR schedule. The flatter the curve, the more investment will increase. This suggests that these are the

only conditions under which companies will always experience complementarity from a subsidy (David *et al.* 1999, 14-17, 19-20).

Figure 4.3: Effect on spending with a grant/subsidy with varying elasticities in MCC



Source: Adapted from David *et al.* 1999.

Looking beyond the level of the individual firm, there is also a danger of crowding out when other private companies choose not to invest in an area in which the public sector is funding “stronger” competitors. In this case, they could assume that those receiving the grants or government contracts have a better chance of profiting from their efforts, thus deeming the level of risk prohibitive (David *et al.* 1999, 17-18).

Returning to the macroeconomic level, the study similarly found that government spending stimulates public demand for inputs, leading to an increase in the price, especially where inputs are finite. This price increase can cause crowding out of private investment unless there is enough spillover created to also raise private demand. Such a price increase can easily lead to ambiguous or erroneous interpretations of performance results, however, because the overall increase in spending caused by inflated prices may be mistaken for stimulation of additional private investment (David *et al.* 1999, 21-22).

David *et al.* (1999) review a number of previous studies conducted at various levels, including line-of-business (LOB), firm, industry and aggregate levels.¹⁵ As a result, they show that deficiencies in current models and lack of comparability make it impossible to draw any definitive conclusions regarding the effect of public spending on private spending and that the diversity of regions, industries and technologies suggests that there is no “right” answer to the question of impact (46). They observed that in a third of the all reviewed cases and in half of those at the LOB and firm levels, public funding crowded out private spending. They also noted that complementarity was seen at firm level or below more frequently in US-based studies, underscoring additional regional differences in the data that appear to be greater at or below the firm level. Further, they point out that complementarity is more likely to occur above the firm level, i.e., at the industry and national levels where substitution effects nearly cease, and that large enterprises are best positioned to take advantage of the benefits. No conclusions are drawn about causes, and questions regarding the impact of spillover, decision-making and price effects are left open (47-49).

In 2000, the OECD published a paper based on findings from a study on government support using grants, tax incentives and public procurement in which they attempted to correct for the previous studies considered in David *et al.* (1999) by testing the effectiveness of all three of these instruments taken together. The study uses a macroeconomic approach in order to account for the effects of spillover, both positive and negative. In the twenty years leading up to the study, government funding of industry R&D dropped from 23% to 10% in the OECD countries, and regional differences in the sources of spending remained among the EU and the US and Japan, as illustrated in Figure 4.4. Additionally, less than 5% of basic research occurred in the business sector, implying the need for public intervention to encourage projects with longer-term potential impact (Guelllec & van Pottelsberghe 2000, 10-13).

¹⁵ See David *et al.* (1999) pp. 26-44 for their detailed literature review.

Figure 4.4: Percentage of R&D spending by source in the EU, US and Japan in 2000

	OECD average	EU	US	Japan
percentage of total R&D activity				
Business	70	63	+73	+73
Universities	17	21	~14	~14
Government / Public labs	11	15	~8	~8
Business R&D funded by Government	10	10	15	1

Source: Adapted from Guellec & van Pottelsberghe 2000, p. 11.

The study demonstrated that direct support in the form of grants or subsidies stimulates private spending at a ratio of 1:0.7 (marginal effect 1.70) but reduces government research and university research by 1:0.44 (marginal effect 0.56) and 1:0.18 (marginal effect 0.82), respectively. Although there is partial crowding out in the last two ratios, the net marginal effect is still positive; however, it is suggested by the findings that knowledge transfer from public to private users may be problematic. When government funding of business increased, the substitution effect diminished, likely due to improvement of sector spillover. The study also concluded that tax incentives, which reduce the marginal cost of R&D, work faster than direct measures but have a shorter-term effect on private investment, most likely because they can often be used for any type of spending at the companies' discretion and, depending on the target group, do not necessarily influence only specific sectors (Guellec & van Pottelsberghe 2000, 13-15; David *et al.* 1999, 9).

Interestingly, grants and tax incentives were found to be substitutes for one another in industry R&D, in that an increase in one reduces the effectiveness of the other. But public support of industry R&D is complementary to university research, which is attributed to improvements in technology transfer when both are supported. This underlines the importance of a coordinated policy mix to maximize the effectiveness of individual instruments. The findings also suggested that defense spending, in particular, is the prime suspect for crowding out because there is little or no incentive for knowledge sharing of the often closely held results, and there is no leverage effect for the R&D-producing firm because it is not the end user of the resultant knowledge (Guellec & van Pottelsberghe 2000, 17-18).

Lastly and importantly, Guellec and van Pottelsberghe (2000, 18) warn about diminishing returns on government spending, which increased private R&D elasticity only up until about 13% in the study's sample and began to substitute above 25%. They are instructive about the need to account for differences in regions and time periods when considering the marginal rate of return, but this is an important finding in light of the EU's call for one third of R&D intensity to be funded by the public sector.

In 2004, the Centre for European Economic Research (ZEW)¹⁶ reported on a German study, which used company data from 1992 to 2000 to analyze the link between subsidies and private spending. The sample consisted of 3779 firm years, of which 588 received grants, and looked at patents as a measure of performance (as opposed to actual numbers of new products, employment growth or lower prices). Their goal was to determine if public spending is a substitute for private spending (deadweight or crowding out) or if it induces additional spending, and if such funding supports projects characterized by a higher risk of failure. This implies that even if the risk of substitution is low, there could be little technological improvement overall because of the risk of project failure. Again, appropriability was cited as the key motivator for public spending (Czarnitzki & Hussinger 2004, 2-3).

In analyzing the results, Czarnitzki and Hussinger (2004) proposed that larger firms are more likely to have the resources necessary to file multiple grant applications and to be considered for federal technology funding schemes. Because grant approval tends to favor companies with positive track records in innovation, grants often go to companies that already have proven results (14-15). The study determined that, while partial crowding out could not be completely ruled out, private spending increased by more than the amount of the grant and technology performance improved in

¹⁶ The abbreviation, ZEW, comes from the German name, Zentrum für Europäische Wirtschaftsforschung, GmbH.

companies receiving subsidies. One possible reason offered is that receipt of the grant reduces overall project risk and may make raising other forms of capital more possible. A sub-sample of SMEs showed an even greater positive effect, delivering an above-average increase in private spending as a result of subsidization (18-19).

In a 2006 study, Gelauff and Lejour (2006, 90) carried out a WorldScan simulation that resulted in a reduction over time of the price increase, seen earlier in David *et al.* (1999), such that crowding out becomes less likely. The goal of the simulation was to model what would happen *if* the Lisbon goal for R&D were reached, not whether it can or should be reached. In order to simulate that the 3% objective is achieved by 2010, rather large subsidies for R&D were inferred in the model, along with some associated costs, and they were calculated with country-specific proportional targets and reductions in red tape, or administrative costs.

The study found that achieving all of the Lisbon goals raises GDP by an average of 12% in 2025, with country-specific results ranging from 4.5 to 26%, by which the currently lowest performing countries experience the greatest improvements. In the model, productivity increases force prices down, and exports increase. Employment increases, but the change in labor productivity is minimal because R&D is not in itself an input. The high and medium technology sectors gain the most benefit because they are the most R&D intensive, and the service sector loses competitiveness. In the baseline, R&D intensity actually falls to 1.1% by 2040, primarily due to faster overall economic growth in less R&D intensive countries (Gelauff & Lejour 2006, 21-23, 82-83).

In a lower bound scenario, which assumes that all new employment is low skilled labor and that the rates of female employment improve over time by way of an 8% point reduction in income tax rates, there is a small positive but short-term effect on private spending. Any price increase for inputs is reduced in this model because R&D labor is not considered separately from other skilled labor, so the resultant risk of substitution is eliminated. Though R&D investment increases, the stock volume does not increase at the same rate, and structural composition shifts to less R&D intensive sectors. In the long run, additional spending matches only the amount of the subsidies; therefore, subsidies must continue to increase to keep up with the targets (Gelauff & Lejour 2006, 14, 28, 90).

In an upper bound scenario, which assumes that the employment ratios remain the same over time, meaning an increase also in highly skilled workers, the effect on GDP is greater and the social benefit is much higher. Spending increases must be sustained, and there are greater variances in country results. As best projects are financed first, additional funding becomes less effective, so the positive impact and productivity gains are overestimated. Here, the increase in R&D stocks to achieve the Lisbon goals, in some countries as much as 300%, is deemed unrealistic. In any case, financing the policy reform measures necessary to achieve the 3% objective requires cost cutting that is not fully accounted for in the model and is suggested as another major hurdle to reaching the targets (Gelauff & Lejour 2006, 14, 29, 91).

Because the marginal increase in R&D spending is so significant in the model, productivity for this additional spending is also called into question. As the most effective projects are completed, the social benefit is likely to cap out (Gelauff & Lejour 2006, 86).

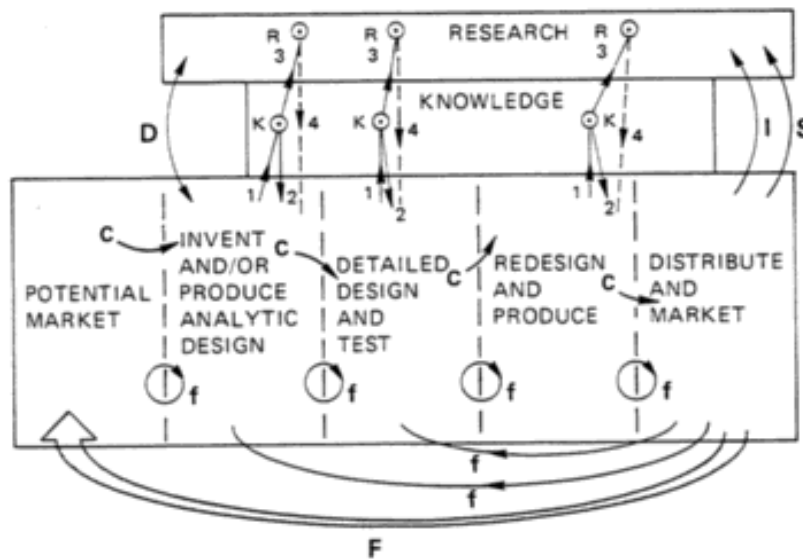
As these studies illustrate, some level of government support is not only justified due to the existence of market failures, but also proves necessary in order to achieve any gains in the R&D indicator and thus in economic growth. But the literature is not conclusive as to the best methods and appropriate levels of intervention. Market failure theory alone neither sufficiently addresses this nor offers definitive answers about where support ends and distortion begins.

4.3 System failure approach

4.3.1 Theoretical background for system failure

To avoid the risk of crowding out and possible distortions from related state failures seen in the market failure approach, a system failure approach is suggested as a complement. To understand how system failures affect innovation, it is first instructive to note that the market failure theory views innovation in a rather simplistic way. A linear model of innovation that progresses from basic research to applied research, then to development and finally to commercialization does not properly account for complexity, and oversimplification can lead to an incorrect choice of policy measures down the line (DG Research 2003, 30). The Kline-Rosenberg (1986) innovation model, seen in Figure 4.5, suggests that innovation does not occur in such a rudimentary linear fashion.

Figure 4.5: Kline-Rosenberg chain-linked model of innovation



Source: Kline & Rosenberg 1986, p. 290.

Note: The model diagram is presented for illustrative purposes only. For a detailed description of the various notations in the figure, a full explanation exists in the source as cited.

In contrast, their chain-linked model of innovation displays a complex and unpredictable process comprised of a series of feedback loops, with research involved throughout (Kline & Rosenberg 1986, 290; Mytelka & Smith 2001, 8). Clearly, trial-and-error and feedback are important components of the internal process as experience leads to new knowledge, and the model illustrates the complexity inherent within the organization. But it also speaks to the external environment where progress is affected by the mutual relationships among producers or between market and producer and by the role of knowledge, which influences how the organization behaves within the larger system in which it operates as new knowledge is created and transferred within the system.

New growth theory tells us that accumulation of knowledge, not physical capital, is a key driver of growth, and knowledge is shaped by the relationships of multiple actors (Aghion & Durlauf 2007; Smith 2000, 86). When fed back into the system and spilled over into neighboring systems, knowledge exhibits increasing returns and muddies the traditional view of a single optimal equilibrium. This bestows great importance on the system itself and suggests that searching out and correcting failures here may be critical to achieving growth, even in the absence of market failures.

The system itself then comprises a number of factors, all of which are thought to have an effect on the behavior of firms. These include socio-cultural issues, framework conditions, regulatory burdens, actors, institutions and infrastructure. All of these elements combine in such a way to influence the decision-making process of companies (Mytelka & Smith 2001, 9; Smith 2000).

The system failure theory has roots in economist Joseph Schumpeter's views on appropriability. Writing on capitalism in 1950, Schumpeter identified not price competition, but rather innovative competition as the true rivalry for organizations, i.e., the ability to generate new products, processes, and technologies (DeLong 2007, B8). Schumpeter's vision of "creative destruction", so named for its resultant destructive effect on some existing products, processes, technologies and jobs in favor of creation of new ones, is exemplified in high-risk technological change (OECD 1998, 1). He claimed that innovation could only occur outside of neo-classical assumptions of perfect competition, and he showed that large firms are those most likely to attempt to shoulder the risk without unquestioning fear of imitation by competitors (Winter 2006, 1101-1104).¹⁷

Failure in the system occurs under various conditions. Smith (2000) has proposed four specific types of system failure, all of which may result in stifling the process of creative destruction. First, *systems can fail to develop into new technological regimes* or secondly, *growth can be stunted by lock-in* of existing ones. Third, *provisions within the infrastructure can be lacking* and thus constitute failure, and fourth is *institutional failure* itself, which may involve policies, regulations and standards.

¹⁷ Both DeLong (2007) and Winter (2006) refer to Schumpeter, J.A. (1950) *Capitalism, socialism and democracy*. New York: Harper and Row.

For example, standards can help technologies to be deployed and complement one another, leading to overall performance improvements and commercial success, but they can also dampen innovation when applied too broadly (Aghion *et al.* 2007, 12), and this type of trade-off is addressed through a system approach.

There is clearly tension between systems that support business as usual and those in which innovation is more likely. The ability of systems to grow and change may be profoundly affected by path dependencies, or the tendency for progress to move along a path shaped by past activities and decisions; however, this does not mean that they are incapable of innovation (Boschma 2005, 249-251). This implies that the keys to correcting for system failure, then, concern encouraging new trajectories, breaking down secure and familiar interdependencies and supporting dynamic ones, and empowering action with appropriate tools.

4.3.2 Empirical evidence of system failure and connection to the Lisbon strategy

Teece (1986) studied why some innovators fail to achieve significant returns on investment. In his findings, he suggested that in addition to risk from imitators, inventions must be combined with other complementary assets in order to be commercialized, providing the example of computer hardware that requires proper software in order to operate (288). But these complementary assets go beyond simple related products, including important factors such as distribution channels, licenses, patents, brand names, reputation and business relationships, and when combined with imitability, help to explain who is most likely to profit and whether or not incentives for innovation exist, as explained by Figure 4.6 (301).

Important conclusions that can be inferred by this model include the higher likelihood of larger companies to have access to necessary complementary assets that might improve chances for success. Also, since profit is difficult when the risk of imitation is high and the hold on assets is weak, there may be greater need for protection of intellectual property, such as patents, in order to incentivize action, despite the associated possibility of compromising knowledge sharing (Teece 1986, 301). Understanding the effect of these factors may help policymakers choose measures that best account for how companies are influenced in a given system.

Figure 4.6: Determining who will profit from the decision to invest in innovation, based on the writings of Teece

		Risk of imitation	
		Strong	Weak
Hold on complementary assets	Strong	Profit to asset holder	Profit to highest bargaining power
	Weak	Profit difficult to secure	Profit to innovator

Source: Adapted from Winter 2006.

System failures may also result from interactions and interdependencies between important pairs of actors: the public and private sectors, university and industry R&D producers, and market entrants and incumbents (O'Sullivan 2007, 11-14). In its 2003 independent study, DG Research published the innovation model shown in Figure 4.7, which lays out the issues, actors and activities present in

a science, technology, innovation and growth system, or so-called STIG system (Aghion *et al.* 2007; DG Research 2003, 34).

Figure 4.7: Actors and issues in a STIG system

	Public sector	Private sector
Knowledge users	Social and human capital - Universities - Training and education	Absorptive capacity - Follower firms, users - Goods and services market
Knowledge creators	Research capacity - Universities, govt institutions - Basic research	Technology/innovation performance - Creative firms - Applied R&D and development

Source: DG Research 2003.

The roles of the actors help to codify the particular areas of concern as shown, and the study found that the correlation between capabilities in three of the quadrants was highly decisive in the fourth, absorptive capacity. The impact on policymaking is explored further in section 6, but here it is important to note that in order to address any of the issues displayed in the four quadrants, it is first necessary to have an understanding of the systemic relationships among these actors. The study concluded that the regional level is best suited for bridging initiatives between sectors and actors, such as knowledge transfer and behavioral changes that directly affect these capabilities. Additionally, it indicated that although well-known best practice instruments such as subsidies and tax incentives for R&D may stimulate private spending in some cases, these instruments alone will be ineffective unless other measures are also taken that consider the framework conditions revealed by a system approach (DG Research 2003, 128).

As noted, both Schumpeter and Teece observed the stronger likelihood of larger firms to successfully shoulder risk. Perhaps because of this, the DG Research (2003) study looked more closely at the role of SMEs in the innovation system and found that in fact overall R&D intensity falls as the SME share of total R&D spending increases, this due to the existence of certain common barriers such as lack of access to external financing, skilled personnel, experienced managers and the benefits of technology transfer (18, 25). This is noted as a weakness for the European Union because the large firm share is much smaller than in the US or Japan, making it that much more difficult to close the R&D gap and achieve the 3% spending objective. Keeping in mind Czarnitzki and Hussinger's (2004) finding that private spending in SMEs is greatly influenced by public subsidies, it also implies that targeted instruments that address these barriers for smaller firms could be highly beneficial.

Brécard *et al.* (2006) used an applied model to determine how R&D expenditures and innovation can drive growth by 2030 within the rubric of the 3% objective. Nemesis, or the economic model for environmental and sustainable development implementation strategies, assumes that knowledge stocks are affected by internal and external R&D activities – i.e., both investment and spillover – and is sector-specific, making it one of the few models to account for the differences in endogenization of technological development by R&D. Within the model, R&D expenditures in the public and private sectors are raised to 1% and 2% of GDP respectively by 2010 and then raised slightly to a combined 3.5% through 2030. The model is then compared to a business-as-usual benchmark (911-915).

In the first phase of the study, a multiplier effect is seen through 2010 in which increased R&D expenditure also raises GDP and productivity, and this increases employment – an important R&D input. As consumption and demand increase, prices inflate causing imports to increase and exports to decrease. This decline in the trade balance slows down the multiplier. During this phase, the model shows employment up by 1.4% and R&D intensity achieving the 3% objective despite the increase to the trade deficit. The second phase, after 2010, is one of innovation growth during which global productivity and product quality improve. Now prices go down, which causes exports to rise again and imports to shrink. Investment and employment growth slow down. This leads to a period

of sustained demand and improvement of the EU's competitiveness in which GDP increases by 12.1% and 10 million new jobs are created (Brécard *et al.* 2006, 917-921).

Moreover, there are interesting sectoral and regional implications in the model. The most R&D intensive sectors, especially high tech, enjoy the greatest benefit, while sectors with little or no R&D suffer. This is true because progress directly affects demand. Regionally, the opposite occurs, wherein there are large variances in efforts necessary caused by differences in the initial levels of R&D intensity and the need for catch-up. The most R&D intense countries make early gains because less effort is required by them at the start, but they lose competitiveness as the catching-up countries increase productivity and product quality much faster in the second phase. Improvement of growth rates ranges from 0.2% in R&D intense Sweden to 2% in Greece. All countries also increase employment, with 3 million of the 10 million new jobs in the research field (Brécard *et al.* 2006, 921).

The study concluded that public support has a positive effect on growth and job creation, and that the economy benefits particularly from expenditures in the high tech sector, in which productivity and spillover improve the most (Brécard *et al.* 2006, 921). While the model anticipates that individual member states all equally achieve the 3% objective, which is not the intention of the European Commission, it is informative to view the growth potential in another way; that is, the burden on each country to reach these growth rates cannot be underestimated. The study does not determine how much increased R&D might actually be necessary in already intense regions to make up for less intense regions. Were it to do so, it is probable that the necessary level of growth would exceed the limitations of the leading regions' current well-developed infrastructures.

Rodríguez-Pose and Crescenzi (2006) sought to combine linear and system approaches to show how various factors contribute to differences in regional performance. They found that while investment in R&D correlated to economic growth in all their regressions and that it has a greater effect than relying only on spillover from other regions, it was not the strongest factor. By controlling for social factors, they determined that internal socio-economic conditions constitute a stronger indicator for growth potential. This suggests that healthy socio-economic conditions increase the absorptive capacity of the region to benefit from spillover and can compensate for some weaknesses in local investment activities. Spillover, however, is not simply a substitute for such activities; rather, the findings imply that favorable conditions may improve the effectiveness of R&D investment and other actions, again emphasizing the importance of a coordinated approach (13-17).

Dory (2008) looked at R&D spending trends and policy measures in nineteen regions in the EU25 in order to determine if particular approaches can be correlated to specific outcomes. He also determined that techno-economic factors have a strong influence on the development of policy approaches and on their likely impact, stating that R&D is just one factor in a larger regional framework that is tasked with broad economic development (4-5).

The study concluded that the critical success factor for a policy mix's impact on growth is concentration on endogenous strengths and that the ability to accomplish this hinges on capacity and available resources. In regions that are less R&D intensive, such as traditional agricultural or tourism areas, the lack of absorptive capacity may cause investments to have less impact, especially in the near term, and may not encourage synergies unless they are deliberately linked to the particular challenges in the area itself. No tailor-made policy approaches were determined for particular regional types, and a system approach accounting for sectors, actors and local issues was advocated (Dory 2008, 16-18).

5 Regional comparative analysis

5.1 Regional typology in the ERA

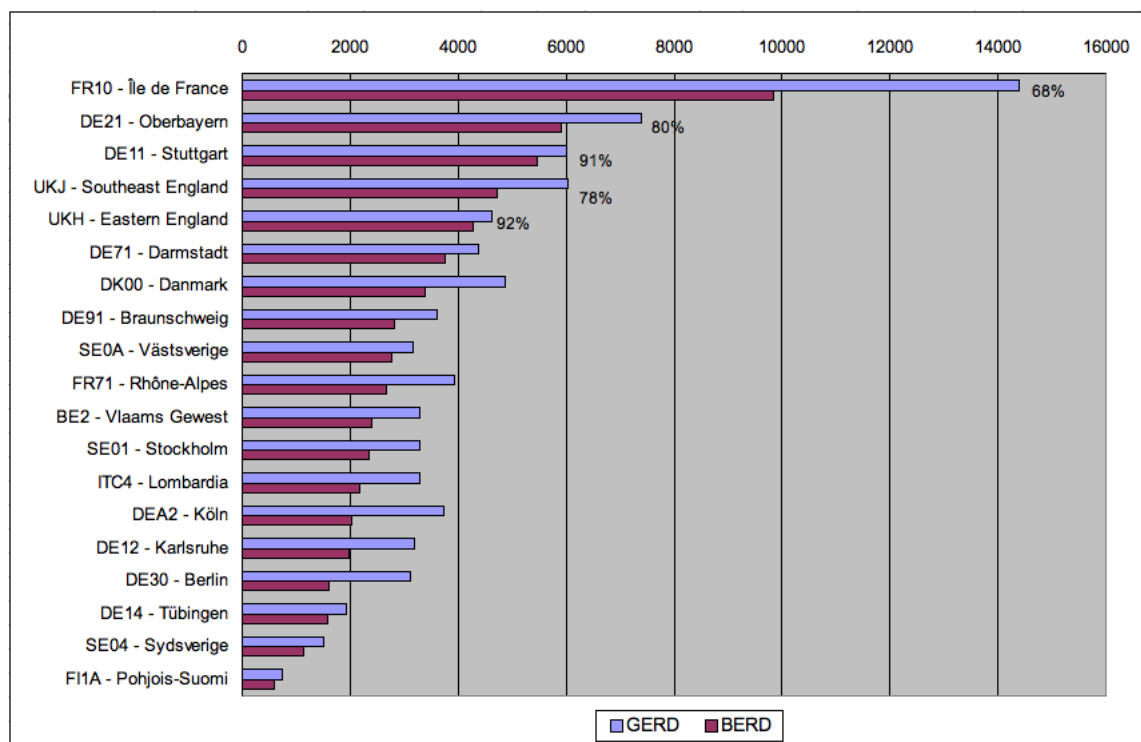
Given the foregoing, the regional level proves a fitting starting point for expedient policymaking for technology and knowledge transfer (Dory 2008; Koschatzky 2005). While the ERA as a whole comprises a diverse range of activities, it is agglomeration and sectoral variances that determine if and to what extent R&D is an important factor in a given region.

As explained, a research system is made up of three primary components: industry, higher education and non-university public research. The balance of strengths, weaknesses and interactions among these groups in a given area shapes the activities in the region. As discussed, there are wide variances between countries of the EU in terms of R&D spending as a percentage of GDP, and the discrepancies are even more significant at the regional level.

Working with the European Commission on data collection of key figures and analysis of regional policies, Fraunhofer Institute for Systems and Innovation Research (ISI) has been looking more deeply into regional performance results in R&D and innovation, primarily at the NUTS2 level. This analysis has resulted in numerous findings and has led to the creation of a regional typology for the ERA.

To get a sense of what is occurring at the regional level and to understand how the typology was developed, it is instructive to look at total and business R&D spending by some of the top performers in the EU. Figure 5.1 shows absolute R&D expenditures in some of these EU regions. It should be noted that these absolute figures deliver different rankings for the results of the top performers than do relative GERD/GDP ratios, but they offer interesting findings nonetheless.

Figure 5.1: Top regional performers in gross expenditures on R&D and business expenditures on R&D (in million Euros) in 2003



Source: Fraunhofer ISI regional key figures database.

Note: Most totals are NUTS2; UK and BE are NUTS1, and UK GERD is from 1999. Percentages noted at the end of the first five columns represent BERD contribution to total GERD.

As seen in the figure, the top performing regions in total absolute spending (upper bar) also tend to be the top performers in industry absolute expenditures on R&D (lower bar), yet there is a rather wide variance in the percentage contribution of BERD to total GERD (Kroll & Stahlecker 2005, 17-18). The ratio for the top five regions, ranging from 68% to 92%, is noted next to the bars in the

figure. This illustrates the relative importance of industry within the region regardless of the amount of absolute investment. With few exceptions, BERD represents a significant contribution to GERD. As can be inferred, the regions also benefit to varying degrees from public sector spending in higher education (HERD), in research institutions and in support of private R&D (collectively, GOVERD). Some areas can be strong in both business and public R&D; for example, Île de France leads European regions in absolute investment in both business and public spending. While this particular region enjoys a strong service-based economy, it is characterized by above average GDP, robust human resources and high capacity for knowledge creation, reflecting a rich and well-developed system (Dory 2008, 15).

The R&D champion in relative terms is the Braunschweig region in Germany, home to the oldest technical university in the country and headquarters of Volkswagen AG, the second highest industry spender on R&D in Europe (DG Research 2008, 16); Braunschweig has the highest R&D intensity in both categories, with 6.8% in private spending and 2.0% in public spending in 2003. In fact, R&D in several areas in Germany, such as Bavaria, including Oberbayern, and Baden-Württemberg, including Stuttgart, Tübingen and Karlsruhe, are influenced by both strong public institutions and by major companies like Daimler, Siemens and BMW, and they are characterized by high GDP per capita and above average R&D intensities. Here knowledge creation and absorptive capacity are high due to well-developed public and private sectors, and even though business R&D spending predominates, public research institutions are significant actors in the system (Dory 2008, 14). This is not typical as it is more likely for regions to tend toward much stronger performance in one category or the other, with a large majority characterized by stronger R&D intensity in business (Kroll & Stahlecker, 17-24).

Kroll and Stahlecker (2005) also found that the regions exhibiting the fastest growth tend to be those areas with low absolute spending in R&D, which is a simple result of taking the percentage against a smaller base figure (19). This was observed earlier in the movement of catching-up countries in the Key Figures 2007 findings from DG Research. This further confirms that a correlation between economic growth and research spending is difficult to measure in both absolute and relative terms and that it is dependent on other external factors at play in the chain-link of knowledge creation and transfer (31). Moreover, as can be noted in the example of Braunschweig, a small number of actors can have a very large effect on performance at the regional level. The Fraunhofer ISI work recommends that the NUTS1 or the NUTS2 level alone cannot fully address all the contingencies that occur in the research system (31-33).

The Fraunhofer ISI typology stems from these findings and also considers output indicators, i.e., the number of patents and publications as a percentage of population. As an aside, it was determined that a model using too many indicators would increase complexity without yielding any significant benefit. Thus, GERD/GDP, BERD/GDP, patents per million population and publications per million population formed the basis of cluster analysis on all NUTS 2 and some NUTS1 regions for Fraunhofer's work (Kroll & Stahlecker 2005, 36-37). This resulted in identification of five regional types:

- Outliers: regions with far above average business R&D,
- Type 1: R&D driven regions,
- Type 2: R&D supported regions centered on the public sector,
- Type 3: R&D supported regions centered on broadly based support, and
- Type 4: regions with complementary (only) R&D efforts (37).

Regions in the first category are referred to as 'outliers' because they are affected by unusually large business expenditures, typically due to very specialized agglomeration. For the purposes of this analysis, the regional outliers are excluded. *Type 1* regions can be broken down into business centered or broadly based areas, thus the output of both publications and especially patents are high. Business expenditures are above average, and GERD/GDP is typically 100% greater than average. *Type 2* regions have very high publications activity and average to above patent intensity. R&D spending, which comes primarily from universities and/or research institutions is above average. *Type 3* regions are moderate in private and public research activity. They yield average publications and patents, with dominance dependent on whether the given region tends more toward public or private orientation, respectively. *Type 4* regions include those in which R&D is less important and those with lagging performance, characterized by low publishing, especially low patenting and less significant R&D spending. Again, these regions may tend more toward either public or private orientation.

5.2 US case studies

5.2.1 Overview

Using this typology as a model, four US states have been identified that correspond to the rubric suggested for each of the regional types above. The states were selected by analyzing their performance in gross state product (GSP) per capita, BERD as a percentage of GSP, HERD as a percentage of GSP, federal investment, patent intensity per million of population and academic articles per million of population. Excluded 'outliers' are California and Massachusetts, which are home to Silicon Valley and the Route 128 corridor respectively.

The states selected are Connecticut (type 1), Maryland (type 2), Arizona (type 3) and Arkansas (type 4). The short case studies consider performance results, key industries and actors, major programs and instruments, successes, failures, impact of federal programs, and best practices.¹⁸ Findings are summarized as applicable to each individual case. An overview in tabular format appears in Appendix C.

5.2.2 Type 1: The case of Connecticut

The State of Connecticut delivers the highest intensity for industry-driven R&D of all US states in 2006 at 3.67% (DeVol & Charuworn 2008, 19) with a patent share (number per million persons) well above the national average. The state scores far below average in federally funded R&D and slightly below average in university R&D intensity, and its publication output is relatively high. United Technologies Corporation (UTC), with business units such as Pratt & Whitney, Sikorsky, Carrier, Otis and Hamilton Sundstrand, accounts for a large share of the state's high technology spending, funded both privately and through military contracts. Other leading companies in Connecticut include Bayer, Unilever, Pfizer Research and Development, General Electric, Xerox, Aetna and UBS. The state focuses on six key industries, namely high technology, manufacturing, financial services, information and communication technology (ICT), health care services and tourism.

The Connecticut Department of Economic and Community Development (DECD) has jurisdiction over business development in the state and has embraced an economic development strategy based on cluster development. The state set up a task force in 1998 to encourage public-private cooperation to support clusters centered specifically on the six key industries identified above. This led to the creation of the Governor's Competitiveness Council, a body made up of chief executives, politicians, and leaders from educational institutions, labor organizations and industry associations.¹⁹ In order to support localized development to encourage clusters around urban centers, the Inner City Business Strategy was developed in 2000, and DECD partners with a number of local and regional economic development organizations.²⁰

The Connecticut Development Authority offers financing and advice to new and existing businesses, guaranteeing loans for those who cannot obtain other forms of financing. Programs target small and early stage businesses up to \$350,000, technology-based businesses up to \$5 million, and information technology projects up to \$750,000. Connecticut Innovations, a program specifically designed to provide capital for several high tech industries was created by the legislature in 1989, quite early by comparison, and has since become self-supporting through its investments.²¹

The state also sponsors the Connecticut Economic Resource Center, a non-profit organization funded primarily by utility companies to provide economic development services (e.g., research and marketing) for local, regional, state and utility organizations. This organization publishes an annual benchmarking report that results in specific recommendations for analyzing progress and improving infrastructure and framework conditions for R&D. A recent concern raised by this and other organizations in the state is the need for strengthening statewide support for technology transfer, which is currently centered at the University of Connecticut's Technology Transfer Center (Innovation Associates 2004).

¹⁸ The case studies were developed solely by the author in cooperation with Fraunhofer ISI's REPOL (Regional Policy Learning) project.

¹⁹ More details are available at www.ct.org/eccd.

²⁰ Such local and regional development agencies throughout the US focus on specific geographical areas within a state with missions to strengthen infrastructure and attract businesses. These organizations are typically non-profit membership associations, driven by participation of local businesspeople and public sector representatives, and they offer services such as conferences, seminars and publications to benefit members. While these organizations operate independently from state government, they look to augment statewide efforts and often serve an advisory function.

²¹ More details are available at www.ctinnovations.com.

In 1994, DECD launched the Connecticut State Technology Extension Program (CONNSTEP) in conjunction with the federal Manufacturing Extension Partnership.²² This program offers management, engineering and industrial support to manufacturing companies to improve productivity and competitiveness. In that same year, the Connecticut Technology Council was formed to connect technology-oriented companies and institutions. The association acts as an advocate for policymaking and works to maximize the effectiveness of the state's strengths, such as the highly educated workforce and risk capital network.

Industry and community development news is heavily emphasized in the state by government agencies and the media, and Governor M. Jodi Rell is a highly visible supporter of new jobs to support the economy. Regional forums are held regularly to involve the public and ensure transparency throughout the state.

Other best practices include community-specific and project-specific loans for targeted areas, enterprise zone benefits, a venture capital platform, an angel investor forum, and programs supporting widespread computer and Internet access. The state supports SMEs through its small business development center and assists start-ups through a licensing information center.

Corporate tax incentives include a match of federal credits for urban and industrial sites, exemptions for manufacturing equipment upgrades and Internet/web costs, and tax credits for investments in new equipment, facilities and human resources. The state offers an R&D tax credit similar to the federal R&D tax credit, allowing 20% for R&D spent within its borders that exceeds the amount spent in the previous year.

In the 2008 State Technology and Science Index, Connecticut improved in all categories of R&D funding and scored in the top ten for R&D inputs, human capital, and science and technology (S&T) workforce. The state received high scores for computer and Internet access and for the number of computer system analysts, despite the recent economic downturn. The state also has a high number of workers with doctoral degrees relative to population, indicating a strong base of technical jobs to attract and retain highly educated workers. Interestingly, the state ranked only 14th in technology concentration and dynamism, despite its focus on clusters (DeVol & Charuorn 2008, 18-20, 32-33, 38-40, 47).

The State of Connecticut seems to have benefited from an early-mover advantage in services and incentive programs that target high technology and innovation; however, states relying on such advantages are ill advised to rest on their laurels or to assume that slow growth rates with otherwise strong indicators are little cause for concern. Currently pending is the Governor's recommendation for millions in capital funds for small business and nanotechnology, underscoring Connecticut's desire to concentrate on areas with future growth potential (State of Connecticut 2008).

5.2.3 Type 2: The case of Maryland

The State of Maryland delivers relatively average results in terms of GSP/capita and industry-funded R&D; however, when federally-funded and university-funded R&D are considered, the state quickly moves into a prominent position, coming in 2nd overall in the nation. With Johns Hopkins University and the state's university system, consisting of eleven universities, two research institutions and two regional centers, along with a number of private and governmental institutions, including the National Institutes of Health, NASA and the US Naval Academy, the state receives a relatively large inflow of federal funds from the Department of Health and Human Services, the Department of Defense, the National Science Foundation, and others. It ranks 2nd in the nation (after New Mexico) for federal R&D intensity, measuring 1.38% in 2006 against a national average of only 0.17%, and is first in the country in university-funded expenditures, at 0.93% against an average of 0.35% (DeVol & Charuorn 2008; Maryland Department of Business and Economic Development 2007, 5).

Through its Department of Business and Economic Development, the state places strong emphasis on public-private partnership and technology transfer. The state's key research industries include the environmental sciences, biotechnology and information and communication technology (ICT), all of which are well-known regional incubators when appropriately nurtured and managed. ICT has been largely credited for contributing to the US global lead in R&D intensity (OECD 2004; DG Research 2003). Although the state scores just near the national average for industry-funded R&D, a recent increase may indicate some transfer success from the public sector.

²² The Manufacturing Extension Partnership (MEP) is a federal program aimed at bridging the productivity gap, identifying growth potential and deploying technology by offering services to manufacturers through 59 MEP centers at 443 locations around the country. A third of the funding comes from the National Institute of Standards and Technology, with the remaining two thirds supported by state funding, partners and/or service fees.

Maryland Technology Development Corporation (TEDCO), an independent body created by the general assembly in 1998, helps to provide seed funding and to propagate know-how in the state. Its Maryland Technology Transfer Fund provides up to \$75,000 to in-state companies who initiate projects that transfer knowledge from a federal laboratory or Maryland university. Similarly, the University Technology Development Fund offers up to \$50,000 to pre-commercial projects that extend research in order to demonstrate the ability to satisfy a market need. The Maryland Technology Extension Service, under the auspices of the federal MEP program, provides advice and technical assistance, and the Maryland Technology Enterprise Institute at the University of Maryland seeks to share university expertise with local firms through entrepreneurship and research programs.²³ Its project, Maryland Industrial Partnership Program, provides matching funds for industry R&D or training that is conducted in collaboration with a university faculty member. Assistance with the application process and with finding university partners is also available. Since its inception in 1987, the program has awarded more than \$140 million, and products have resulted in a reported \$14.4 billion in sales, thousands of new jobs and new technologies.²⁴

The state's portfolio includes a number of other good practices. The Maryland Venture Fund provides seed and early-phase equity funding, of which 60% supports ICT and 40% funds life sciences. The state issues direct loans and guarantees (including at the regional and local levels), has a taxable and non-taxable bonding program in place, and provides \$15,000 to \$50,000 in working capital loans to incubators. It also actively supports SME participation in the federal Small Business Association programs (SBIR and STTR²⁵) from its small business development center, which is a partnership between the federal agency and the University of Maryland and links private, educational and government actors.

Bettering the federal program of R&D tax credits, the state allows for both basic and growth-related credits: a 3% credit on basic R&D expenditures plus an additional 10% for expenses that exceed a company's four-year average. Additionally, there is a tax credit available to investors in biotechnology firms equal to 50% of the investment, up to \$250,000. The state also offers enterprise zone benefits and sponsors the One Maryland tax credit for investment in qualified projects in disadvantaged regions.

Key to Maryland's strong showing in federal R&D funding is its location adjacent to Washington, DC and the number of federal offices that are headquartered there. Perhaps due to the influence of these institutions, the state has an exceptional university system. With a large number of bachelor and advanced degrees represented in the state's science and engineering positions, the workforce is highly educated and higher education appropriations are sizable. Maryland leads the nation in the State Technology and Science Index human capital investment composite (DeVol & Charuworn 2008, 30, 33).

While Massachusetts maintains its strong first place showing in the ranking for R&D inputs, Maryland recently passed California and Colorado to place a not-so-distant second in this category. Maryland also scored high in venture capital investments, especially relative to GSP (DeVol & Charuworn 2008, 19, 26).

Its strengths in ICT and life sciences coupled with its emphasis on technology transfer have helped link state-of-the-art research facilities with industry in Maryland. Because universities and research institutions tend to attract innovative businesses and start-ups, the state has designed its commerce and economic policy to encourage public-private partnership, to create jobs in order to retain its highly trained graduates and to push for a move from basic to applied research (DeVol & Charuworn 2008, 16).

Illustrating a desire to capitalize on a local strength, the state created the Maryland Stem Cell Research Fund in 2006 under the auspices of TEDCO but overseen by a commission of experts, bioethicists and high-level public leaders. The \$15 million fund bridges a gap in federal funding and seeks to accelerate biotechnology development in the state from basic research to preclinical trials, emphasizing collaboration and the potential for economic benefits.²⁶ The new Maryland Biotechnology Center is scheduled to open in early 2009, bringing together public and private initiatives for the sector through marketing, networking and grantmaking.

²³ More details are available at www.choosemaryland.org.

²⁴ More details are available at www.mips.umd.edu.

²⁵ **SBIR** is the Small Business Innovation Research Program, which provides highly competitive grants from eleven federal agencies to support technological advancement and commercialization in small high tech businesses.

STTR is the Small Business Technology Transfer Program, which encourages public-private partnerships between small firms and non-profit research institutes or universities through competitive grants offered by five federal agencies.

²⁶ More details are available at <http://www.mscref.org>.

5.2.4 Type 3: The case of Arizona

The State of Arizona scores squarely in the mid-range for all R&D intensity indicators; however, business here tends toward high technology areas, and a number of clusters have been in place since the early 1990s. Key industries are aerospace, electronic components and tourism, and the state is the birthplace of a number of medical/technological advances, such as the artificial heart and infrared remote-sensing instruments (Arizona Department of Commerce 2006). Leading companies include General Dynamics, Raytheon, Honeywell, Boeing and Lockheed Martin. US subsidiaries of foreign firms include Cemex, Siemens, Deutsche Telekom and Nestlé USA. Arizona State University, based in Phoenix, has several links to industry, including Avnet, VLSI, Cytec Fiberite and Motorola SATCOM, and a major research park. The University of Arizona in Tucson is one of the top 20 public research universities in the country and one of the top 10 NASA grant recipients for its work in space science research. Throughout the current decade, the state has received increasing federal funding for its colleges and universities, primarily for basic research and defense-related equipment and systems. In the life sciences, the state hosts the Mayo Clinic and the Arizona Research Center, which focuses on the pharmaceutical industry.

The Arizona Department of Commerce is charged with overseeing economic research and initiatives within the state through its Commerce and Economic Development Commission (CEDC). This agency, formed in 1989, oversees the CEDC fund to support economic development and provides an advisory function for policy, particularly for long-range planning. It does not implement strategy but takes a large role in setting priorities. In 2006, the CEDC launched a ten-year economic plan, entitled "Moving Arizona Forward" (Arizona Department of Commerce 2006), which provides very specific goals for economic growth, regionalism, R&D and talent retention. The plan breaks down strategies with clearly detailed tactics and action items. It was informed by a statewide economic study conducted in 2002 as part of a public-private partnership.

The department also includes an Office of Innovation and Technology (OIT), which serves as a resource for the high tech industries in the state. The office is responsible for implementing strategies set by the Governor's Council on Innovation and Technology. In 2007, OIT launched the Innovation Accelerator program, which includes a number of specific non-tax-based initiatives aimed at technology development and commercialization. They provide AZ FAST grants to entrepreneurs to assist them in grant writing for federal SBIR and STTR funds. The Market Assessment Program funds feasibility studies for marketing and licensing strategies, while the Technology Assessment Program provides expert reviews on the uniqueness and marketability of new technologies and the value of intellectual property protection. The program fosters transparency through an online resource center and its weekly e-mail newsletter, Arizona Innovation Connection.²⁷

Also in 2007, the Governor introduced a non-profit entity called Arizona Economic Resource Organization (AERO) to stimulate public-private partnerships. The group is comprised of representatives from industry, the Department of Commerce, CEDC and other agencies, along with the presidents of the state's universities. The goal is to guide policymaking and strategy in a more harmonized fashion by bringing together all of these stakeholders, strengthening partnerships and coordinating efforts. The initiative is the result of a one-year study on economic development practices.²⁸

Historically, more than half of the measures employed in Arizona are tax-based incentives. The R&D tax credit is a 20% allowable credit based on the federal computation method. The state also offers an angel investor tax credit for qualified investments in rural or bioscience companies. There are also incentives that target specific communities, such as Tucson, and enterprise zones. Companies can benefit from accelerated depreciation, which encourages capital investment and reduces personal liability. Other tax credits are offered for military zone reuse, pollution control, solar energy and motion picture production. Besides the obvious effect on jobs and tax revenue, the latter is of interest because the state's economic plan emphasizes tourism and film production as stimulators of brand awareness, which, they contend, translates into companies choosing Arizona as a business location (Arizona Department of Commerce 2006, 16). In this way, a specific instrument targeted at a regional specialization not usually associated with R&D generation, i.e., tourism, is employed to attract and retain R&D-producing firms.

The large number of military installations in the state explains the sizeable amount of federal R&D support in the defense sector, and it also creates a significant number of jobs and billions of dollars in revenue. The state also benefits from its proximity to the State of California, the "outlier" that leads the nation in high tech industries and jobs. In addition to benefiting from knowledge spillover, Arizona is well positioned to attract California firms looking to expand, especially given its

²⁷ More details are available at www.azcommerce.com/BusAsst/Technology.

²⁸ More details are available at www.azcommerce.com/About/AERO.htm.

comparatively low wages and low taxes (Governor's Council on Innovation and Technology 2005). Recently, the state increased its sales factor for multi-state corporations and lowered business property tax liability.

On the down side, the state suffers from a lack of a venture capital platform. The state may then be less attractive for those firms seeking early-stage capital. Additionally, the state is dependent on a relatively small number of industries, which means that it may be more vulnerable to unfavorable macroeconomic conditions.

Arizona's 2006 ten-year economic plan highlights public-private partnerships to encourage the most beneficial investments and regionalism as a basis for targeting actions and leveraging resources. In the State Technology and Science Index, Arizona retained its overall ranking at 17 from 2004 to 2008, though it significantly improved its position in technological concentration and dynamism, dramatically moving from 17th place to 6th place in that category. Despite the weaknesses in VC, the state has a large number of new businesses and initial public offering (IPO) proceeds relative to GSP, with a reported 1.4 "Inc. 500" companies per 10,000 firms. The state delivered mid-range results in other areas and scored its lowest category ranking in human capital investment, coming in at only 33. Combined with a technology and science workforce ranking of 22, there is an implication that the state needs to look more carefully at incentives for talent that could improve its overall showing, given that skill and creativity are essential for economic growth (DeVol & Charuworn 2008, 26, 29-46). It currently offers a job training grant, which represents a healthy start.

The state appears to do very well in codifying and disseminating its objectives. In addition to the clearly delineated goals in its ten-year plan, the state makes good use of digital tools (web resources, electronic mail), hosts "listening sessions" throughout the state, and has launched the Arizona Indicators project to improve transparency and share data.²⁹

5.2.5 Type 4: The case of Arkansas

The State of Arkansas continues to score well below average in all categories of R&D intensity, particularly in industry funded R&D. But despite its poor showing, the state posted 32% growth in GSP between 1998 and 2004. Its key industries are agriculture, such as poultry and rice production, manufacturing, services and tourism. Tyson Foods, J.B. Hunt and Wal-Mart have global headquarters in Arkansas, and the state also hosts large operations for Pilgrim's Pride, Whirlpool, and several automotive parts makers. The University of Arkansas System has a number of campuses and a prominent medical school, which is associated with many hospitals and research institutes. The FDA's National Center for Toxicological Research is located in Arkansas.

The Arkansas Economic Development Commission, which oversees policy incentives and instruments, workforce development and technology assistance, places emphasis primarily on basic research. Its matching grant program awards funds to colleges and universities receiving federal funding. The program focuses on multi-university efforts to foster collaboration and improve statewide impact. Applied research grants provide a match for science and engineering transfers, but the state's technology transfer assistance program has an FY09 annual budget of only \$350,000 and individual grants are set at a mere \$3750.

The Arkansas Science and Technology Authority (ASTA) was created in 1983 to support efforts in S&T and to monitor results. Initiatives operated by this authority include a seed capital investment program, which offers up to \$500,000, and a technology development program to assist innovation projects that develop products and processes for commercialization with grants of up to \$100,000. Under this program, two projects were funded in 2007 with a combined total of \$60,000. These programs focus on stimulating efforts particularly in the high tech and biotechnology sectors (Arkansas Science & Technology Authority 2007a).

ASTA approved a 2008 research and development plan in September 2007 that lists a number of specific research areas of importance to the state under the following headings: advanced materials and manufacturing; biotechnology, bioengineering, agriculture and life sciences; information technology; and human resources. There are no action items or other explanatory details associated with the list (Arkansas Science & Technology Authority 2007b).

Arkansas Manufacturing Solutions (AMS) is an ASTA initiative that provides technical and business assistance to the state's manufacturing and industrial sectors, in collaboration with the federal MEP program. AMS helps to improve productivity and profitability through training and implementation projects. ASTA also has a mandate to strengthen science, technology, engineering and mathematics (STEM) education, and it endeavors to improve awareness of this goal and to make resources available to schools, including curricula, teacher training and a grant fund. The agency

²⁹ More details available at www.arizonaindicators.org.

also offers training programs to new businesses and those with new technology needs in selected industries.

A tax credit is available to firms that partner with universities and companies in early-stage development and knowledge-based ongoing research. Further, an R&D tax credit of 20% is available for qualified in-house expenditures and donations in specific industries. The state has a \$4 million seed capital investment fund offering loans of up to \$500,000 for start-ups and technology expansion projects and hosts the Arkansas Venture Forum, which provides a VC networking platform. SMEs are specifically targeted through small business loans and a business development center, although it is comparatively less aggressive and comprehensive than in some other states.

Accelerate Arkansas, a volunteer consortium of 60 business and university leaders dedicated to fostering economic growth in the state, underscores the fact that the state continues to be in a catching-up mode through its sponsored studies, including an Arkansas-specific 2004 report from the Milken Institute addressing future policy options, and reports from the University of Arkansas 2010 Commission – sequentially entitled "Making the Case", "Picking Up the Pace", "Gaining Ground" and "Raising the Bar" – address higher education funding issues.³⁰ In contrast to ASTA's industry-focused plan, these reports make specific recommendations, though they are primarily restricted to university-focused issues. But this level of involvement indicates that unlike some of the catching-up regions in the ERA, the state has developed at least a generic research system.

Arkansas apparently has rather limited resources and is in the midst of addressing the challenge to best put those resources to use. Lack of focus, coupled with comparatively inadequate incentives for businesses, contributes to its poor showing. It scores dead last for R&D inputs and for the number of doctoral engineers in the State Technology and Science Index. In 2008, it improved its score for risk capital and entrepreneurial infrastructure, but it still ranks 48th overall in the nation and, without strong institutions and incentives aimed at start-ups and early phase development, progress continues to be slow (Milken Institute 2004, 9).

Recommendations and efforts in both public and higher education seem well placed given that strong university systems are vital for stimulating research in a region and increasing relationships that lead to clustering (DeVol & Charuworn 2008, 16). Technology transfer programs and incentives could be strengthened to facilitate this process. Also, despite strong standardized test scores for college admissions, the state is challenged with the need to address talent retention and attraction. Although property taxes and health care costs are attractive, the state has relatively low wages and high personal taxes, making it less attractive to highly skilled workers (Milken Institute 2004, 4).

The National Science Foundation (NSF) named Arkansas one of 27 jurisdictions eligible for the Experimental Program to Stimulate Competitive Research (EPSCoR). This program seeks to enhance research funding at the national level by supporting R&D efforts and developing strategies to support university infrastructures and research competitiveness. Arkansas EPSCoR works collaboratively with other state organizations, particularly ASTA, to improve the environment for entrepreneurship and innovation. In 2008, the NSF awarded ASTA a \$9 million grant to be distributed in its basic research funding program over three years. This award significantly increases available funding for university projects, which totaled only \$664,541 in 2007 (Arkansas Science & Technology Authority 2008; Arkansas Science & Technology Authority 2007a). The effect of the grant is yet to be determined, and the state must develop its strategy to best leverage these dollars for the future.

5.3 Case study analysis

Despite their differing placements in the typology, there are a number of similar instruments in place among the four states profiled. Some of these instruments, such as the technology extension programs and small business assistance programs, are clearly linked to the federal policy level. This supports van Pottelsberghe's (2008) claim that the US benefits from its relative homogeneity. At the same time, there is no centralized innovation policy in the US, and even at the national level, there is a rather high level of decentralization among a number of key agencies, for example, for defense, aerospace, energy and health. Although this may result in some inefficiency, it likely allows for flexibility in the framework conditions (Rammer *et al.* 2007, 6-8).

The US federal research system is characterized by very similar objectives to those of the EU. Specifically, priorities include support for R&D-producing companies, technology transfer from the public sector to industry and education and training initiatives. Policies are typically bottom-up developments that result from assessment and monitoring by both government and independent bodies, such as the American Association for the Advancement of Science and the Council of Competitiveness, both which produce reports and reviews that lead to recommendations. Though

³⁰ More details and reports available at <http://chancellor.uark.edu/13134.php>.

the system is decentralized, there are complex checks and balances in place that allow these separate entities to pursue their objectives in a way that it is once both coordinated and agile. But it is at the state level that many instruments are most effectively employed because of their influence on regional universities and local industry (Rammer *et al.* 2007, 9-11, 21, 25-27).

Each state employs a unique mix of these rather similar instruments, and in some cases policies appear to be customized to specializations or regional conditions. An example is the special sector tax incentive, which targets manufacturing upgrades in Connecticut, biotechnology in Maryland, and solar energy in Arizona. What is less clear is a classic chicken-and-egg question: which came first, i.e., do the policies reflect careful consideration of key actors and industries or is the existing sectoral composition a direct result of applied policy? While it is out of the scope of this paper to definitively answer this question and the literature remains indeterminate on this point, a few conclusions can reasonably be drawn.

All of the states profiled have programs in place that speak to public-private cooperation and technology transfer; however, this is addressed through a variety of instruments, including financing schemes, tax incentives and grants, and to varying levels. In Connecticut, programs like CONNSTEP favor a strong industry focus. In a state characterized by high tech manufacturing and, as in Braunschweig, dominated by a single large corporation, this seems fitting. Even though defense spending, which the OECD study found to be more likely to crowd out, is a large factor in the state, the Governor's office firmly supports clusters and by solidly concentrating them on the state's six key industries, there is both a clear focus on regional strengths and a rather healthy diversity of action areas.

In Maryland, which is characterized by a high level of university and public research, one of the state's most compelling programs deals directly with collaboration and technology transfer by providing funding to advance marketable knowledge and push it from the exceptionally strong university system to companies, and thus to the market. If results are correctly linked to action, this program represents billions in revenue, and industry R&D is on the rise in the state.

Arizona, an early adopter of the cluster strategy where R&D performance is about average, has initiated new coordinated efforts to support public-private partnership, such as AERO and the ten-year economic plan, just in the past year. An independent economic research advisory committee suggested a new strategic opportunity fund aimed at encouraging firms and researchers to collaborate with universities and non-profit research institutions rather than simply investing in individual firms (Poole *et al.* 2005, 53). This led to the 2007 creation of Science Foundation Arizona, a partnership that provides a fund for basic research and public-private cooperation. Surely, the fruits of these efforts are yet to be determined. Already, the state emphasized SME support through its AZ FAST grant writing assistance program, market and technology assessment grants, and angel tax credit. Despite having no formal venture capital program, new businesses and IPOs are attracted to the dynamic environment, likely due to the emphasis on industries with future potential, and the state boosts brand awareness with a clever tax break for film projects.

The State of Arkansas, which ranks well below the national average for all R&D expenditures, places emphasis on basic research, and the STIG system lacks strong measures to ensure cohesion. Although there is a technology transfer assistance program in place, it is poorly funded when compared to more R&D intensive state programs. Its technology development grants for new marketable products and processes look promising, but with only two grants awarded in 2007, the program is not packing much of a punch. The state demonstrates concern, however, with recent developments targeting S&T education and a new strategic plan in the making. While lagging regions are cautioned against confusing catching-up with imitation, the state's emphasis on S&T education and relative strength in its university system could prove beneficial for a better-developed technology transfer program (Mazzoleni & Nelson 2007). Unfortunately, Aghion and Durlauf (2007) report that an additional \$1000 per person in research education spending contributes to an increase of 0.27% in a technologically advanced state's productivity growth rate and only 0.09% in a state that is lagging far behind (21).

In keeping with Dory (2008), who determined that regions appear to be most successful concentrating on strengths by fine-tuning initiatives that support absorptive capacity, the first three states profiled have tailored programs that address technology transfer within the confines of their own specializations, and the lagging state is clearly shown to be weak in this area. These cases demonstrate that attempts to increase absorptive capacity rely on injecting capital and providing fiscal incentives and financial assistance; however, this may be implemented in various forms and to varying degrees in order to capitalize on local strengths, and the degree to which they are successful varies based on the region's competences.

Further, the emphasis on clustering, which is a clear priority for leading business R&D driven Connecticut and for Arizona, is a system-based approach that considers numerous stakeholders. By encouraging broad interaction among actors and a wide range of instruments within the cluster,

it is likely that knowledge sharing is increased and, in turn, the needs of the actors themselves then help to determine strategy (DG Research 2003, 38). This is especially critical because alliances themselves can lead to increased complexity, so the benefits must be clear (Lord *et al.* 2005). Such an approach addresses technology transfer and absorptive capacity in a more coordinated and holistic way.

Another clear success factor is that financial markets in the US are more open to funding new entrants and new sectors (O'Sullivan 2007, 12). This is illustrated in the case studies through rather robust venture capital and angel networks in the strongest R&D performing states and also is true of the US as a whole.

Lastly, in addition to the ability of US innovation systems to account for specializations through regionally appropriate mixes and targeted programs, many widespread instruments in use are neutral and avoid the pitfall of picking winners that can lead to distortions, or state failure. General assistance programs, like many small business loans and generic R&D tax credits, level the playing field. These instruments form a very important foundation on which to build policy mixes, and at least one expert group concluded that emphasis on these instruments in the US has led to better diffusion of technology than in other countries, such as France, where the public sector has had a stronger hand in supporting specific technologies (O'Sullivan 2007, 12).

At the same time, the size and performance of the ICT sector in the US is attributed to non-neutral support of public research and training. Although this particular example may be the result of a fortunate series of actions that are difficult to replicate, this argues for a complementary approach to selecting and balancing both neutral and non-neutral instruments in the policy mix that is at once decentralized and coordinated (Aghion *et al.* 2007, 19, 24).

6 Policymaking and instruments

6.1 The implications for policymaking

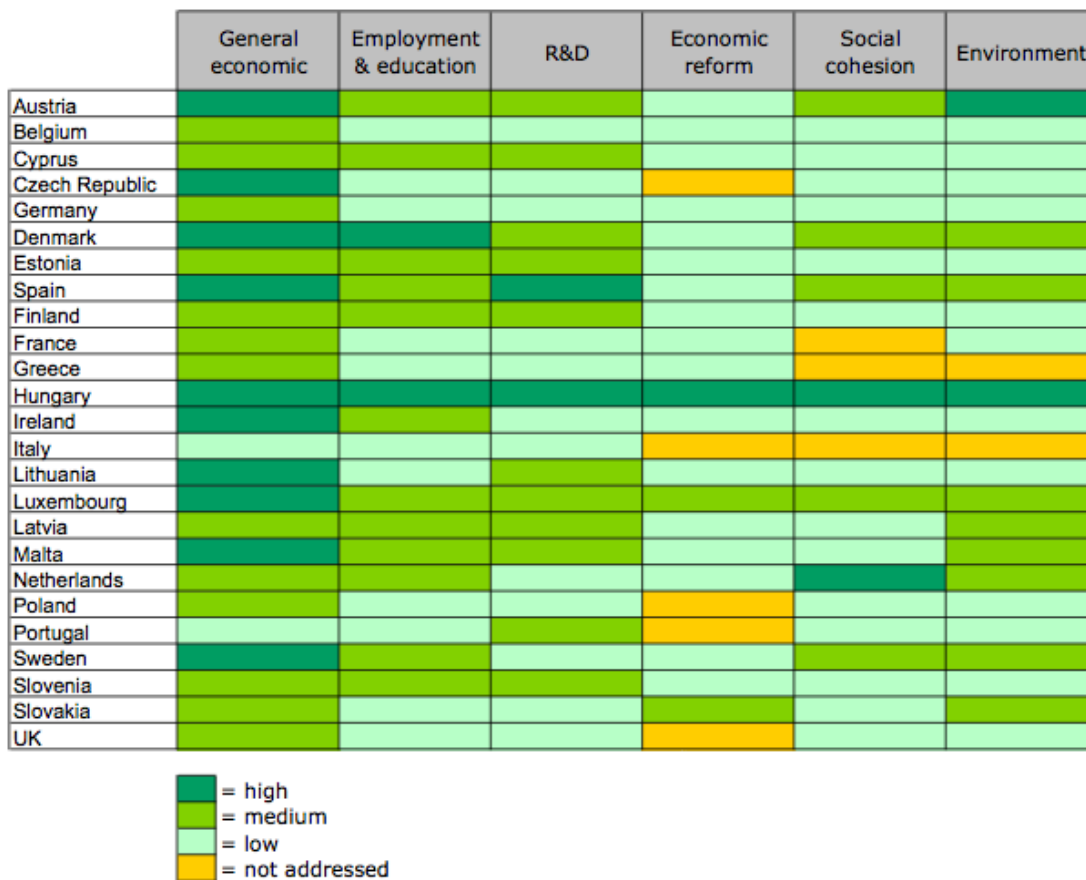
The OECD (1998), among others, attested that advances in technology feed economic growth. Throughout the literature, this point is affirmatively repeated and widely accepted; therefore, it is understood here as a given (Dory 2008, 5; Freeman & Soete 1997, 291). However, the inability to determine a definitive theory linking innovation to growth and a well-defined approach that considers both macro and microeconomic effects has led to stunted policymaking that centers on somewhat disconnected strategies for talent and ideas and trial-and-error instrument mixes (Mytelka & Smith 2001, 16; Boschma 2005, 262).

Aghion *et al.* (2007) discuss insights from the literature regarding organizational design. They state, "...where the program involves high inputs of specialized expertise, where information on which resource allocation should be based is not symmetrically distributed, and where activity planning is highly contingent on the uncertain outcome of sequential production stages, decentralization of agenda control and flat organizations are preferable..." (15), albeit within a framework of well-defined instruments.³¹ But the EU has bemoaned the problems of coordinating efforts, and implementation backlogs have been blamed on inertia in member states' governments (Sulmicka 2005, 9).

Through their national action programmes, individual EU member states are required to report annually to the European Commission on plans for reform in line with the Lisbon strategy goals. These plans must address steps taken and focus on innovation poles (EC 2005b, 15, 31). Aghion *et al.* (2007) and others clearly favor such a decentralized approach but point out continued problems with both coordination and inertia. The individual targets are likely too ambitious in any case when measured at the member state level (van Pottelsberghe 2008, 4). The coherence between indicators used in the plans and the EU structural categories is detailed in Figure 6.1, pointing to the strengths and weaknesses of the individual member states' plans thus far. High or medium results indicate strong or moderate coherence between the country's plan and the EU structural categories. Low results imply that indicators are not in line. Areas not yet addressed are also noted.

³¹ Aghion *et al.* (2007) refer to Sah, R.K. & Stiglitz, J.E. (1988) Committees, hierarchies and polyarchies. *Economic Journal*, 1988.

Figure 6.1: Coherence between indicators in the national action programmes of the EU25 and the EU structural categories, March 2008



Source: Steuer *et al.* 2008.

Although some positive steps have been taken, it is clear that overall progress on coherence is poor in most member states. This has been attributed to macroeconomic conditions and to poor strategy, including delays, barriers and contradictions in the plans and the slowdown in completing the single market (Sulmicka 2005, 9; EC 2004, 9-10). Only Hungary and Luxembourg reach high and medium marks in all structural categories, and all other member states exhibit much room for improvement.

Looking at the figure from the perspective of the structural categories themselves is also instructive. While general economic conditions have been addressed to a fairly comprehensive level across the board, the other categories, including R&D, show mixed to weak results. Economic reform and social cohesion, which heavily influence conditions in the STIG system, are in need of attention as too many member states have low coherence or have not addressed the use of indicators to measure and monitor progress in these areas (Steuer *et al.* 2008).

It is important to keep in mind, however, that progress at the member state level does not properly account for regional dynamics; van Pottelsberghe (2008) determines that "...there is no basis for the setting of EU-wide or country targets in the Lisbon programmes unless the EU's intention is to determine member states' industrial structure" (5). Recalling the role of specialization, it would seem that there is a natural conflict at play here – on the one hand, differences in regional performance are desirable because they focus strengths on an appropriate division of labor and allow for economies of scale; but on the other hand, assessing the 3% goal at any level below the EU level implies that all regions are equally responsible for achieving this objective. This explains the EU's struggle with coordination efforts aimed at regional efforts. The real challenge is for policymakers to take advantage of the benefits of agglomeration while being realistic about their limits.

Dory (2008) observed that the objectives of the Lisbon strategy have been specifically implemented in only a few regions, despite an increase in awareness that research and innovation support growth efforts (34). While no single policy area in isolation is likely to have a transformational effect (DG Research 2003, 28), Oh and Heshmati (2005) determined that investment in R&D is likely the most important element in improving competitiveness and technology and creating new jobs. In their study of Lisbon strategy indices, they showed that concentration on high performing areas reveals that these economies involve high labor productivity and high unemployment – perhaps a

necessary trade-off. Conversely, lower performing areas tend to lack new technologies, market competition and property rights (Blanke 2006), placing emphasis on policies that address these weaknesses.

Again, the example of Baden-Württemberg in Germany is instructive. Here, the state provides support for correcting possible market failures, but robust networks and a healthy infrastructure also characterize the region, and locally defined priorities provide the incentive for firms to push for new technologies (Koschatzky 2005, 302). It is likely no coincidence that, as in the US, the R&D system in Germany is relatively decentralized. Additionally, in the state's regions that are strong in university research such as Karlsruhe and Tübingen, cluster development has helped to break down the "ivory tower" mentality that characterizes the chasm between industry and academics in other regions (Mazzoleni & Nelson 2007), and patenting is high. Importantly, local or regional policy can influence knowledge spillover, especially where its tacit nature tends to keep it bounded, and it can be sensitive to the changing needs throughout the lifecycle of the cluster (Smith 2000).

6.2 Linking instruments to objectives

6.2.1 Policy mix and best practice instruments

Best practice should not be confused with simple imitation, in which a country or region implements a policy mix without necessarily deeply contemplating its potential effectiveness and the region's absorptive capacity (DG Research 2003, 35). And similar policy mixes can have different outcomes in different regions depending on the composition of the area and the way in which they are implemented (Dory 2008, 4). Boschma (2005) warns, "It is impossible to imitate and copy these successful areas by other regions that lag behind..." because of the specialized nature of growth in systems (253). It is therefore important to consider that the mix of instruments should discourage lock-in to the extent that it can.

While public support programs may appear to involve neutral instruments, that is, those that are available to all and do not allow for the practice of picking winners, many such programs actually make use of non-neutral instruments. These include loan programs for particular types of small businesses and grant programs that target specific industries, as illustrated in the US case studies. While such instruments might be seen as problematic for competition policy and capable of creating new and unforeseen market effects of their own, there is reason to support them. Aghion *et al.* (2007) cite non-neutral research and training investments that have had a significant influence on the US lead in the high tech sector. They advise that it is, in fact, a harmonic design of such policies in conjunction with competition policy that neutralizes the drawbacks of non-neutrality (19).

The instruments available to policymakers can be categorized into those specific to R&D policy, which are designed specifically to raise investment levels and target market failures, and those that speak to framework conditions and target system failures.

6.2.1.1 R&D and innovation policy instruments

Because R&D policy instruments aim to increase investment, these instruments are financial or fiscal in nature. DG Research (2003) classified them into three types: direct measures, indirect measures and catalytic measures.

Direct measures comprise instruments by which the public sector directly supports private sector activities. These typically include non-neutral instruments such as grants/subsidies and conditional loans, programs that benefit public-private collaboration and public procurement.

Indirect measures involve instruments that reduce public revenues rather than increase public expense. Such instruments include tax incentives and some additional SME programs. These instruments can be non-neutral, targeting specific industries, but they are generally broad enough to be considered neutral.

The catalytic measures are those that influence access to sources of private funding. These include risk capital measures, such as angel networks and private equity, and programs that guarantee loans and other forms of equity. These measures involve bolstering support to reduce perceived risk and make R&D actors more attractive for financing. This is critical in the EU where SMEs are so dominant, and it is particularly compelling in light of reports that the significant growth in business R&D share from SMEs in the US is propelled by increases in VC funding, which far exceeds that in the EU (DG Research 2003, 26).

6.2.1.2 Framework policy instruments

One of the most important activities here is public research, which takes place in universities and in institutions. Much research at this level is basic research, which Stubbs (2001) called the "...bedrock of technological progress..." because, although there is high risk of failure and a long time may be needed to recoup the investment, this research is most likely to be disseminated widely and spillover to other regions and sectors (144). But important applied research is also conducted at this level. Related is infrastructure support, in which public funds may be used to provide the buildings, equipment and conditions under which such research can be carried out.

Other types of public support include classifying areas with favorable designations, which confer certain benefits. Centers of excellence, innovation poles and empowerment zones, though they focus on different areas, serve to highlight and encourage activities that support economic growth. In the latter, tax incentives and regulatory relief are typically employed. The European Regional Development Fund (ERDF) serves these zones as part of the EU's regional policy.

Also key here, as previously discussed, is technology transfer. Particularly beneficial are programs that encourage public-private partnerships so that new knowledge can be both continuously pushed forward and fed back into the innovation system. Spillover within and among STIG systems can also be stimulated so that knowledge is shared with some of the less intensive regions.

Attention to policies supporting human capital is an important component. This is currently an especially interesting area for the EU as free movement among member states becomes easier; however, there are still regulatory discrepancies that may limit real mobility (EC 2007b). As illustrated in the case studies, there are differences among US states as well, but these differences are minimized by the homogeneous nature of the overall market. Without the same benefit in Europe, these differences may make it much harder to attract and retain talent.

Another important framework consideration is the use of standards. While there is much debate in the literature about the dampening effect of standards on innovation, they also can push knowledge diffusion and deployment and result in improved performance and commercialization (Aghion *et al.* 2007). For example, ICT norms and standards are needed to ensure that complex products developed among a wide range of actors can be integrated for the good of the entire industry (OECD 2004, 52). A related instrument is protection of intellectual property, which has a direct influence on willingness to invest and take risks but may affect spillover.

Lastly, reform of state aid rules in the EU ensures that funds can now more directly target R&D projects. Previously, the amount of subsidies that companies could accept to prevent market failures was limited. Without a clear way to measure whether or not distortions had been corrected, an argument was made for the need to provide incentives for increased private R&D investment, and the rules were amended in favor of less restricted support (DG Research 2003, 129).

Framework policies by nature require a high level of coordination. Generally, the larger and more mature the STIG system, the more diverse the measures must be and more attention must be given to interdependencies (DG Research 2003, 38).

6.2.2 Identifying key actionable issues and linking instruments

Only by narrowing down key regional problems can a policy mix be properly developed, tested and implemented. This is particularly crucial as Dory (2008) found that only a few regions in the EU have considered specific objectives in shaping policy approaches (5). Aghion & Durlauf (2007) propose diagnosing the strongest constraints to growth in order to identify critical concerns, but they caution that the focus not be too narrow, which could lead to solutions that address only the demand side or only the supply side (13). That is, interventions should target both increases in supply capacity and the development of demand to ensure deployment and diffusion into the system (Aghion *et al.* 2007, 12).

Due to agglomeration and the special circumstances inherent in the widely heterogeneous regions in the EU, it is advisable that a short list of key actionable issues be identified in each region in association with its member state's national action programme. DG Research (2003) provides a model that can assist in matching appropriate instruments to specialized needs for the EU as a whole (113), which can be adapted at national and regional levels. They illustrate the model using a sample of four specific targeted action areas that must be addressed in the EU to increase R&D performance. These are:

- attracting new foreign multi-national corporations (MNCs) that have strong R&D capacity,
- increasing the investment from existing companies,
- creating new R&D-intensive start-ups in the SME sector, and
- encouraging R&D activity in firms with little or no existing capacity (23).

These four key routes to action serve as the objectives in the model. To illustrate how individual systems can evaluate the potential influence of various instruments on regional priorities, Figure 6.2 shows the relative importance of the individual instruments outlined above for each of these key actionable issues. The supposition here is that such an analysis weighs the relative importance of these instruments according to the particular needs of the region, thus revealing a road map for assembling a mix of instruments that best addresses actionable goals and makes use of often limited resources.

Figure 6.2: Importance of policy instruments to objectives

Linking policy instruments to key objectives				
	Attracting MNC capacity	Increasing existing investment	Creating R&D intensive SMEs	Encouraging low-tech sector R&D
R&D and Innovation Policy				
Direct Measures				
Grants	Important	Very important	Less important	Less important
Collaboration	Important	Very important	Less important	Less important
Public procurement	Very important	Very important	Important	Less important
Indirect Measures				
Tax incentives	Very important	Important	Important	Less important
SME-specific assistance	Less important	Important	Very important	Important
Catalytic Measures				
Risk capital/angel networks	Less important	Important	Very important	Very important
Loan guarantees	Less important	Important	Very important	Very important
Equity guarantees	Less important	Important	Very important	Important
Framework Policy				
Public research	Important	Important	Important	Less important
University funding	Important	Important	Important	Less important
Infrastructure support	Very important	Important	Important	Less important
Centers of excellence	Important	Important	Important	Less important
Empowerment zones	Important	Important	Less important	Important
Technology transfer	Very important	Very important	Very important	Important
Human resources	Very important	Important	Important	Important
Standards	Very important	Important	Less important	Less important
Intellectual property rights	Important	Important	Less important	Less important
State aid rules	Important	Very important	Less important	Less important

Key: = Very important
 = Important
 = Less important

Source: Adapted from DG Research 2003, p. 113.

The model serves as a good starting point for shaping policy mixes that integrate and emphasize these measures to the degree that makes sense in light of particular regional issues. DG Research (2003) reports, "There are a limited number of roads to increased R&D investment but many ways of traveling along them" (135). Further, they recommend seeking complementary relationships among instruments, as suggested in the case study analysis. For example, non-neutral indirect measures that target very strategic areas may be complemented by neutral direct measures that have a broader focus, assuming that they are designed in such a way that they do not substitute for one another. This is a relevant suggestion for the EU, where Union level measures tend to be direct in nature, and indirect measures, such as tax incentives, are initiated at the national or regional levels, offering greater opportunity for coordinated efforts (136).

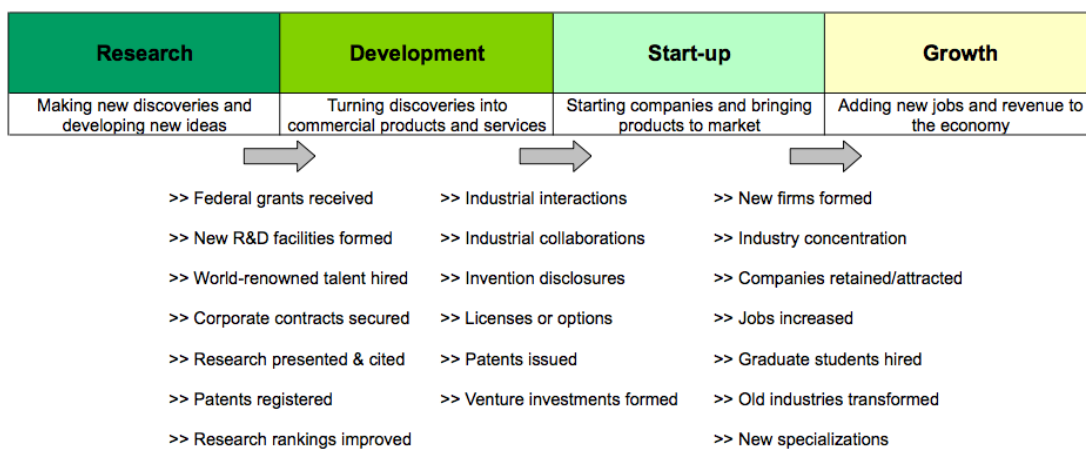
6.3 Measuring impact

After linkages are made and limited resources are earmarked, ongoing evaluation is necessary to ensure that the selected measures deliver desired results. Aghion *et al.* (2007) recommend cost

benefit analysis, in which the price of deferring action is compared against the cost of getting it wrong (25-26). But because of the interdependencies inherent in the system itself and among the instruments, it is highly likely that test cases will be neither effective nor scalable. At the same time, frequent policy changes that attempt to chase trends are doomed to failure.

Instead, policymakers should monitor a set of indicators that measure short-term wins and long-term results. The Pew Center on the States (2007) suggests that while this is as individual as a region's own policy mix, a number of universal keys apply. These include: measuring both direct and indirect benefits; reflecting local needs; making sure they are transparent and shared on a timely basis; using multiple measures to test the movement of research to the marketplace; getting support from all applicable stakeholders; continuing to refine and change measures as necessary; and employing an independent reviewer (57). Figure 6.3 illustrates some of the possible indicators that can be put to use at various steps along the innovation lifecycle to measure the impact of actions taken.

Figure 6.3: Possible indicators to measure progress along the innovation lifecycle



Source: Adapted from Pew Center on the States 2007, p. 58.

These quantifiers may be applied such that they address the universal keys noted by the Pew Center; however, caution is warranted, particularly where large time lags may occur and cause and effect may be unclear. Of primary importance here is the movement of knowledge and creation of absorptive capacity such that the marginal return on R&D efforts is increased (Kroll & Stahlecker 2008).

6.4 The influence of the social model in Europe

Within the EU, the stability pact places higher value on stability over growth. The resultant lack of flexibility makes Schumpeter's creative destruction more costly and discourages radical change (Aghion *et al.* 2007, 22). Schumpeter believed that "...governments could not maintain enough social insurance to counter the destructive part of capitalism without strangling the sources of rapid growth" (DeLong 2007, B8). Dedication to the social model may be in direct conflict with Europe's ability to support the level of innovation, and thus growth, sought by the EU, and it deserves a closer look in the near future.

Deep-seated "securimania"³² exists, in which protecting jobs at all costs gets in the way of flexibility. In a Friends of Europe (2008) lunch debate, Unilever CEO Patrick Cescau called for "flexicurity" stating, "It is irresponsible to try to protect jobs that cannot be protected from the competitive standpoint. Rather, it is important to try to protect the people by offering them education, training and lifelong learning opportunities. That's where our social responsibility lies" (5).

EFTA (2007) echoes an often repeated concern about the aging population in Europe and the potentially disastrous impact on the social security system. In their 2007 Lisbon update, they recommend efforts to persuade workers to remain longer in the labor market (9); however, companies, apprehensive about getting stuck with bad hires, also need to be encouraged to continue to value older workers and provide opportunities for keeping skills fresh and productivity high.

³² Securimania refers to inflexibility and low tolerance for risk associated with certain cultures, such as is seen in a number of influential European countries with strong social models.

In contrast, the US benefits from an agile business environment. Without any appreciable barriers between regions, mobility is a given, and the employment market is highly flexible for both employers and employees (Rammel *et al.* 2007). In the 2008 Doing Business project (World Bank 2008), the US received a ranking of 1 out of 178 countries for employing workers due to the ease of hiring and firing, low non-wage costs and virtually no mandatory costs for terminating employees. Japan ranked 17th and the UK ranked a moderate 21st place; however, Germany, arguably the economic champion of the EU, came in at 137th place due to its rigid social structure and extremely high cost of firing.

Additionally, because the business sector most responsible for the gap between the EU and US is ICT, it is important to note that the business environment for entrepreneurs and start-ups is more hospitable in the US. Again, looking at the 2008 Doing Business project, the US scores a ranking of 4 for starting a business (World Bank 2008). Not only are the number of steps, number of days and costs quite low, but there is no paid-in minimum capitalization requirement. Risk aversion, a well-known cross-cultural indicator often associated with several European countries, and red tape were cited by the Aho report (EC 2006) as principal obstacles for EU participation in the high tech sector. Interestingly, in the Scandinavian countries where risk aversion tends toward the lowest in Europe, R&D intensity is the highest.

Finally, 22% of US companies in the world's top 1000 (by market capitalization) were created after 1980 versus only 5% in Europe, and of those, over 70% are IT companies (DG Research 2007a, 11; O'Sullivan 2007, 9-10). This implies that agility and flexibility, especially in new technologies, is a key component of competitiveness. Policies that are designed to address barriers to private spending on research or innovation are likely to be more effective than those that simply increase public expenditures (O'Sullivan 2007, 2).

7 Conclusion

There is little doubt that increasing R&D and innovation is critical to growth and competitiveness in Europe. If one assumes that market failures exist in R&D and innovation, the important question is not *if* public intervention is an appropriate stimulus, but rather *how much, to what end and in what form* should such support be provided. A system approach to innovation policy compels a close look at actors, institutions and the socio-economic environment at the community, national and regional levels.

Regional variances, then, are perhaps the most important factor influencing the development of an appropriate policy mix. While this means that policymaking must necessarily account for local specializations, it is also clear that institutional factors are involved that can be affected by centralized coordination, such as labor and competition policy. The main objectives – and thus challenges – for regional policymaking are: stimulating the efficiency of the system; encouraging dynamic connection among the actors; and reducing the risk of lock-in on the regional level while still building on local strengths. Additionally, it is necessary to consider institutional framework conditions that will stimulate structural change where needed (Boschma 2005, 260-264).

It is apparent that neither single actor nor single instrument solutions will have appreciable effects on R&D intensity or productivity, and policies aimed at some stakeholders will have effects on other actors (DG Research 2003; Guellec & van Pottelsberghe 2000). Complicating matters is the difficulty of measuring the impact of actions taken, which is clouded by unclear time lags, complementarities and trade-offs among measures (Oh & Heshmati 2005, 5).

Market failure theory helps to explain only why the public sector must take action, and system failure theory provides a platform from which to identify key problems and link the appropriate actions, taking into account the complexity inherent in the system itself. Sectoral composition, infrastructure, human resources and the learning process ingrained in a region determine how actors interact and share knowledge. Policymakers must continuously seek weak links in the chain, address them and assess progress, again recognizing that single instrument solutions cannot succeed (DG Research 2003, 39).

The literature demonstrates that policymakers are best advised to focus on instruments that remove barriers to investment, market entry and to change (O'Sullivan 2007; Smith 2000). It is also clear that spillover alone, while very important at the local level, is not as effective as outright investment (Rodríguez-Pose & Crescenzi 2006). Money, it seems, can have more direct influence than knowledge; but policymakers must use caution. In order to take risks, firms benefit from stable programs that they can count on, and government intervention that is either too low or too high has been shown to be ineffectual, for example, by increasing the possibility of substitution (Guellec & van Pottelsberghe 2000; David *et al.* 1999). Directing limited resources appropriately should act as a stimulant for industry risk-taking and as a multiplier for federal/supranational funding.

Taking the case of Arizona, where the potential for important high tech industries is very promising and R&D intensity is about average, the policy mix relies on a number of tax incentives, both neutral and non-neutral. This does not necessarily square well for a state that places strong emphasis on a handful of very specific emerging technologies, especially if young firms cannot yet benefit from the incentives because their revenues have not reached sufficient levels or they depend more on workers than on capital investments. In this case, direct measures could be more beneficial. While other US states have increased these types of investments in the last decade, Arizona has only recently focused on strong measures to support broader technology-based strategies. An example is the lack of a robust venture capital program in the state to provide start-up and early seed capital. To their credit, Arizona policymakers have worked hard to make changes, coalesce efforts and reduce disparate strategic objectives among actors in the system. The AERO initiative is an excellent example of applying the system approach through public-private partnership and bringing all the parties together at the same table.

Concurrently, it is important to consider that the region must not rely solely on its potential in the high tech sector. Over-reliance on too few industries is a risk, and more work in the area of sectoral diversification is recommended. This is instructive to consider for both targeted areas, such as NUTS2 regions, which may focus too narrowly on only one or two industries, and to the larger system. As demonstrated, a policy mix must strike a balance between continuing to emphasize specializations and providing a broad base for economic security, particularly to weather economic downturns.

In regions experiencing catch-up, improving the infrastructure for technology transfer emerges as suggested good practice. While this strategy takes advantage of the cluster approach, it also addresses absorptive capacity in hopes of speeding up the typically slow results of basic research (OECD 2004). This is also demonstrated in the case of Maryland, where initiatives aimed at strengthening collaboration have resulted in billions in industry revenue in a state dominated by public research.

For the EU as a whole, striking a balance between decentralization and coordination remains a key challenge, and the US system of checks and balances unfortunately does not offer an imitable model due to the heterogeneity of Europe. Sulmicka (2005) and Oh and Heshmati (2005) make a case for looking closer to home, suggesting that successes in Scandinavia could reveal valuable insight; this area is recommended for further study in the future.

For now, the EU is advised to focus on slower but longer-term direct measures and the elimination of barriers to mobility and flexibility and to look very closely at how limited resources are allocated, such as grants (FP), loans (EIB) and structural funds (ERDF and ESF). To flourish, the ERA must be attractive to investors and talented individuals, offering training and incentives. The internal market must be extended and deepened to maintain competitiveness, while regulations and infrastructure must support systems at the national and regional levels where indirect measures, which are shorter-term but have longer lasting benefits, are more likely to be initiated (O'Sullivan 2007; DG Research 2006; EC 2006; Sulmicka 2005).

Finally, the influence of globalization creates a "moving target" effect that only complicates the picture. A report from Friends of Europe (2008) warns that world conditions have changed in the eight years since the Lisbon strategy was set such that the goals themselves need to be reconsidered. These conditions include links that cause chain reactions on a global scale, such as the recent crises in financial markets and rising prices for food and energy (8). In a climate of uncertainty, consistency and clarity are never more necessary, and while a system approach that considers regional characteristics and regional priorities may prove more difficult than ever, it is also likely critical to success.

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Appendix A: Selected EU actions for research and innovation³³

1951 Treaty of Paris

Article 55 provides for the power to support research related to the production of coal and steel, occupational health and to improve contacts among research institutions

1957 Treaty of Rome

Articles 163 to 173 allow for broader and deeper involvement in research activities and provides opportunity to develop a research and training program

1958 European Investment Bank (EIB)

Established by the Treaty of Rome, it is the long-term lending institution of the EU and continues to evolve with community objectives

1960 European Social Fund (ESF)

First structural fund established by the Treaty of Rome in operation, provides grants to areas with less advanced economic development to promote economic and social cohesion

1967 Directorate-General for Industrial Affairs

Creates a central body to coordinate policy

1971 European cooperation in the field of scientific and technical research (COST)

Encourages European coordination in S&T research by recommending specific "Actions" and providing central support activities while necessitating national funding

1974 Council adoption of four resolutions

Concerns coordination of national policies for science and technology (S&T), participation in the European Science Foundation, an action program for S&T and an action program for forecasting, analysis and methodology

1974 Committee for Scientific and Technical Research (CREST)

Established to oversee development of community-wide RTD policy and coordination with member states

1975 European Regional Development Fund (ERDF)

Provides direct aid, infrastructure and technical assistance to enhance economic and social cohesion in disadvantaged areas

1977 European Patent Office (EPO)

Provides a single application process for patents in 38 European countries

1981 Information Technologies Task Force

Supports a Round Table of leaders from 12 companies to discuss the future of the IT sector

1984 European Strategic Programme on Research in Information Technology (ESPRIT)

Launches a pilot program for collaboration in the IT sector, which serves as a model for future industrial programs; integrates R&D projects with technology transfer measures; last call 1998 when incorporated into framework programme

1984 First Framework Programme

Dedicated multi-year program to support research that stresses interaction and coordination of R&D activities

1985 European Research Coordination Agency (EUREKA)

Supports competitiveness in high technology industries by offering its label to cooperative projects (involving at least two countries) that can then seek funding from national research budgets

1987 Cohesion criteria

Establishes principle of subsidiarity in order to reduce differences across national and regional policymaking with EU level policymaking

³³ Compiled by the author using a number of sources, but primarily Georgiou 2001, Stubbs 2001.

1987 Single European Act

Article 130f fully establishes the framework programme to implement policy for science and technology

1989 Strategic Programme for Innovation and Technology Transfer (SPRINT)

Sought to create innovation friendly and absorptive environment; ran through 1994

1992 Maastricht Treaty

Article 130f-p strengthens framework programme by making it central for all R&D activities and allows for a broad range of topics from basic research through commercialization actions

1996 First Action Plan for Innovation in Europe

Encourages coordination on fostering an innovation culture and environment, exchanging best practice and promoting the framework programme and urges member states to address bureaucracy, incentives and training issues

1997 Amsterdam Treaty

Changes decision-making for the framework programme from a unanimous vote to a qualified majority in the Council of Ministers

1997 European Investment Fund (EIF)

A joint venture of the EIB, the European Commission and private lenders, services the SME community with early-stage and tech-oriented venture capital and guarantees

1998 Fifth Framework Programme

Adds social objectives to the project criteria

2000 European Research Area (ERA)

Recommends a formal network for coordinating centers of excellence, research facilities, instruments and human resources and a common system for policymaking

2000 Lisbon European Council: Lisbon Strategy

Aims to make the EU the most dynamic and competitive knowledge-based economy in the world by 2010

2002 Barcelona European Council: 3% goal

Sets the Union-wide R&D goal for the Lisbon strategy at 3% of GDP to be spent on R&D, with 2/3rds to be funded by industry

2005 European Research Council (ERC)

Funds and encourages investigator-driven frontier research in an effort to stimulate new industries and markets and to strengthen the overall research system

2005 i2010

Provides a framework for ICT policies and actions to address challenges of the information society

2007 Research Executive Agency (REA)

Currently organizing to manage tasks in FP7 for the European Commission

2008 European Institute of Innovation and Technology (EIT)

Plans to boost public-private partnership to leverage commercial opportunity and bridge innovation gap

Appendix B: Country-specific results of the Lisbon Review 2006

Variables for scoring used in the Lisbon Review 2006 index by category:³⁴

Information society for all: government priority and promotion of ICT, use of online services, development of ICT-related laws, ISP competition, company use of the Internet, student access to the Internet

Innovation and R&D: technological readiness, science and engineering jobs, university and public research, absorptive capacity of companies, spending on R&D, collaboration with universities, government procurement based on innovation, protection of IPR

Liberalization: competition in local market, number and quality of suppliers, standards and regulations, anti-trust policy, corporate activity, foreign ownership, FDI rules, agricultural policy, neutrality of policies, distortion of competition by fiscal measures

Network industries: phone lines and cellular service, number of subscribers, infrastructure, roads, railroads, air transportation, quality of electricity supply

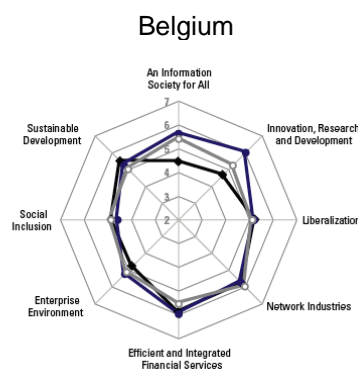
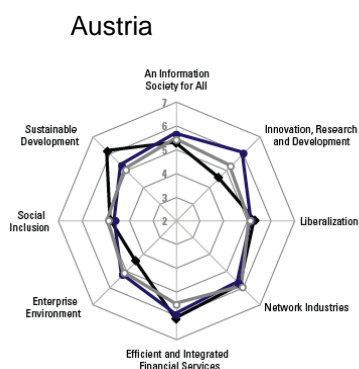
Financial services: property rights, sophistication of financial markets, banks, ability to raise funds by issuing shares on local stock market, auditing and reporting standards, money laundering

Enterprise environment: starting a new business, obtaining a bank loan with no collateral, access to venture capital for risky projects, red tape, tax level, transparency of regulations, resolving contract disputes

Social inclusion: pay relative to productivity, equality of women's and men's wages, access to government-provided child care, unemployment, education, human resources

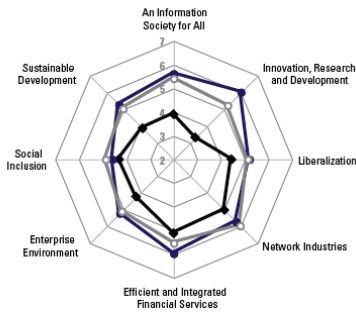
Sustainable development: environmental regulation, companies' attention to the ecosystem

Figure 8.1: Radar diagrams of Lisbon Review results for the individual EU25 countries and EU25 average

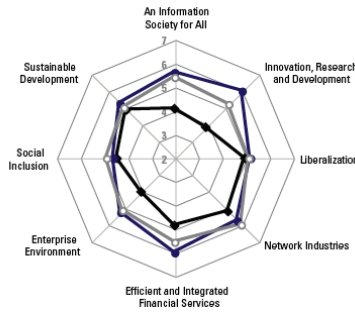


³⁴ Precise scoring and weighting are provided in Blanke 2006, pp. 17-18.

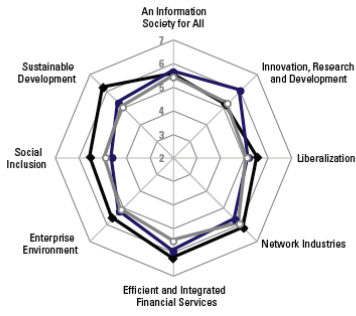
Cyprus



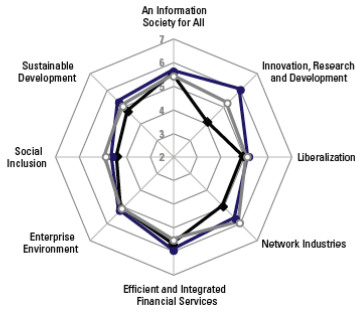
Czech Republic



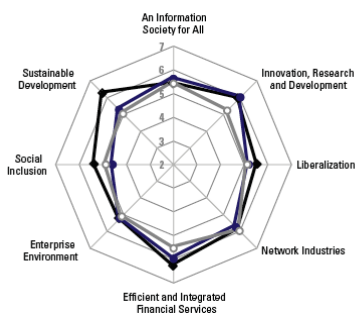
Denmark



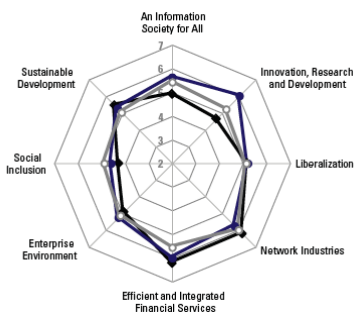
Estonia



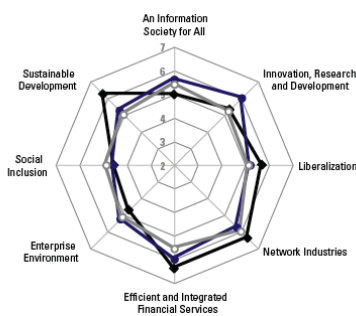
Finland



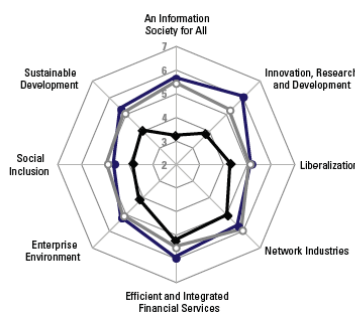
France



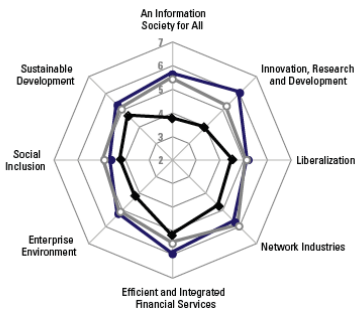
Germany



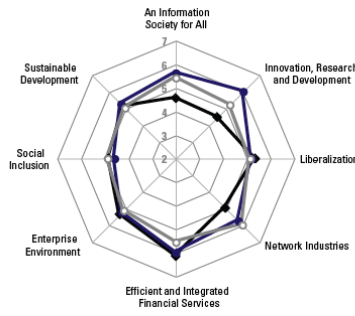
Greece



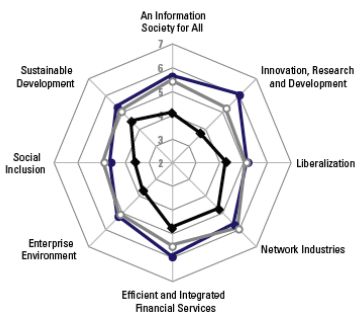
Hungary



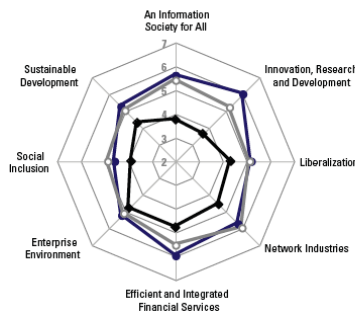
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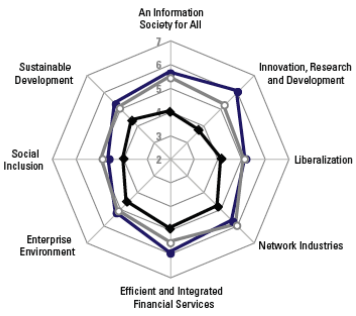
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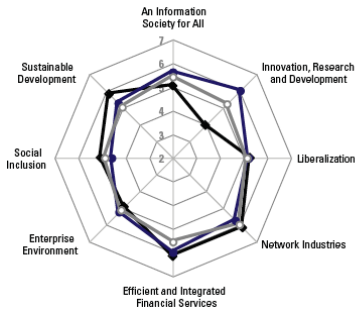
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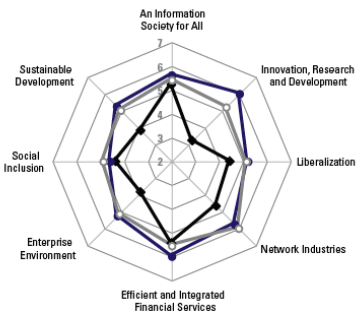
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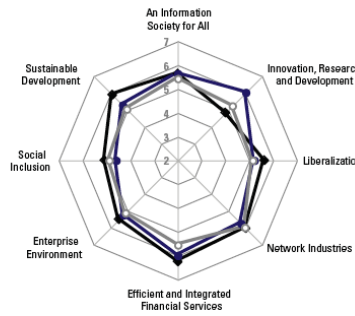
Luxembourg



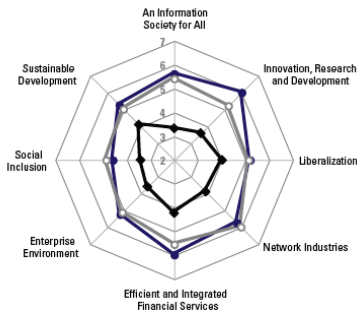
Malta



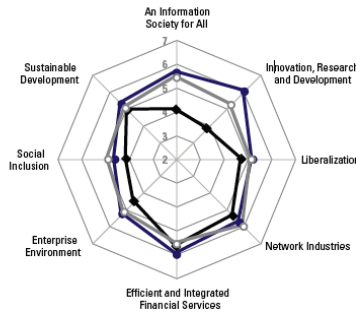
Netherlands



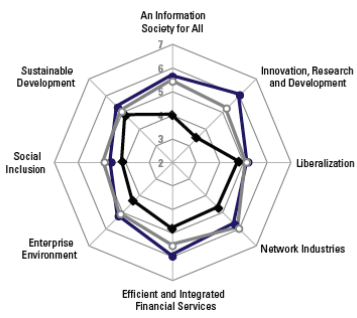
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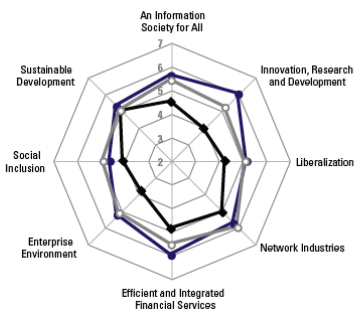
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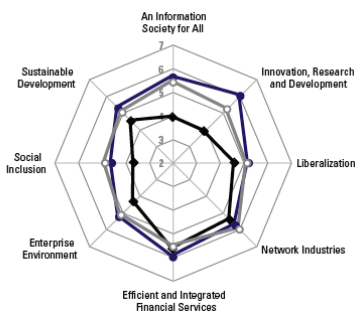
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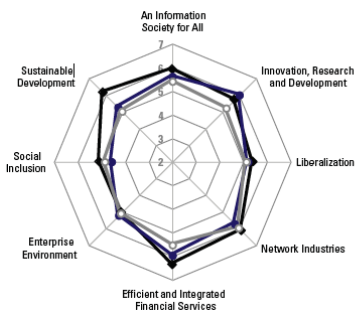
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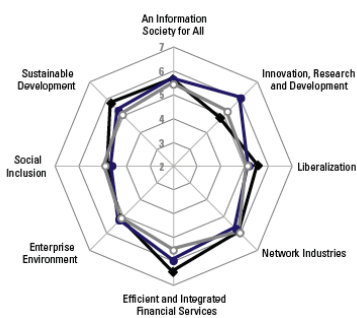
Spain



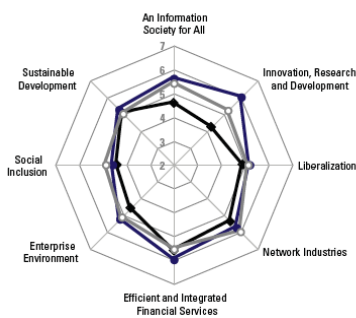
Sweden



United Kingdom



EU25 Average



Source: Blanke 2006, pp. 13-16.

Appendix C: Overview of US case studies in table format

Regional type	Baseline	Industry research driven (Type 1)	Academically oriented (Type 2)	R&D supported (Type 3)	Complementary R&D efforts / Lagging (Type 4)	
Region	Federal	Connecticut	Maryland	Arizona	Arkansas	
General rubric		high share from business 100% above national average; very high patents and high publications	slightly above average intensity; average patents and very high publications	average publication and patent output; not known as the top tier centers of excellence	R&D less than central at present; very low patents; may be involved in catching-up activities	
Indicators (2006):						
GSP/capita	\$41,452	\$54,558	\$43,046	\$38,972	\$30,262	
Federal R&D intensity	.17	.06	1.38	.16	.08	
Industry R&D intensity	1.75	3.67	1.88	1.86	.31	
University R&D intensity	.35	.32	.93	.31	.19	
Patents	164293	1577	1313	1621	132	
Patents per m pop.	287	451	236	282	48	
Academic articles (2005)	166453	3145	5506	2459	743	
Articles per m pop.	293	899	990	428	270	
Rankings:						
2004 State Tech & Science Index	na	10	4	17	49	
2008 State Tech & Science Index		7	2	17	48	
Details:						
Authority:	US Department of Commerce	Connecticut Department of Economic and Community Development (DECD)	Maryland Department of Business and Economic Development	Arizona Department of Commerce	Arkansas Economic Development Commission	
Related agencies and organizations:	National Science Foundation (NSF)	Connecticut Economic Resource Center (CERC) - nonprofit funded by utility companies, research and marketing services		Commerce and Economic Development Commission (CEDC) - funded by lottery	Arkansas Science and Technology Authority (ASTA)	
	National Institute of Standards and Technology (NIST)	Connecticut Technology Council - advocates on policymaking	Maryland Technology Development Corporation (TEDCO) - seed funding/know-how	Office of Innovation and Technology (OIT) - resource for high tech industries		
	Small Business Association (SBA)	Connecticut Development Authority - financing schemes and advice, loan guarantees	Task Force on the Future of Growth and Development - insuring smart growth and land use	Science Foundation Arizona - builds research programs and infrastructure - funded with match		
	Manufacturing Extension Partnership (MEP) - resource network tied to state programs	Connecticut State Technology Extension Program (CONNSTEP) - management, engineering and industrial support	Maryland Technology Extension Services - advice and technical assistance	Arizona Manufacturing Extension Partnership - provides information and knowledge for innovation strategies	Arkansas Manufacturing Solutions (AMS) - technical and business assistance	
Key industries:	na	Manufacturing Financial services Telecomm / information Health care services High technology Tourism	Environmental science Biotechnology ICT Transportation Defense / aerospace	Tourism Defense / aerospace Electronic components Life sciences	Manufacturing Services Agriculture - poultry, rice	
Special initiatives:	SBIR - Small Business Innovation Research - budget set-asides for funding	Governor's Competitiveness Council - nurturing clusters	Capital Access Program - credit enhancement for targeted industries	Governor's Council on Innovation and Technology - strategy development	Arkansas Community of Excellence - strategic planning	
	STTR - Small Business Technology Transfer Program - set-asides for partnerships	University of Connecticut's Technology Transfer Center	Neighborhood BusinessWorks Program - below market gap financing for locating or expanding in revitalization areas	Arizona Economic Resource Organization (AERO) - to stimulate public-private collaboration and codify strategic direction	Accelerate Arkansas - volunteer consortium of business and university leaders dedicated to fostering economic growth	
	Licensing Small Business Investment Company firms	Inner City Business Strategy - urban focus	choosemaryland.org - detailed info resource for outreach to potential businesses	Moving Arizona Forward - a ten year economic plan for specific goals and detailed action items	University of Arkansas 2010 Commission - recommendations for higher education challenges	
	American Competitiveness Initiative	Industry Cluster Initiative - focuses on six key industries	Maryland Stem Cell Research Fund - accelerates biotech from basic to preclinical trials	Arizona Innovation Accelerator Program - angel network, market and technology assessments	Arkansas EPSCoR - improving the environment for entrepreneurs	
	e.g., WIRED - offers grants to selected regions to improve talent retention	Connecticut Innovations - capital for high tech industries, self-supporting through investments	Industrial Partnership Program - matches funds for public-private collaborative projects	e-Resource Center and Innovation Connection - e-news resource		
Other direct and catalytic measures:	Technology Innovation Program (TIP) - awards up to 50% costs on high risk/high reward projects (SME/unis)	Direct project-specific loans	Direct loans and guarantees	CEDC loans and grants	State matches federal funds awarded to colleges and universities	
	SBIC to support VC and incubators	Venture capital platform	Maryland Venture Fund - state funded seed and early equity fund		Venture capital investment fund and Arkansas Venture Forum	
		Angel investor forum			Angel investment forum	Seed capital up to \$500K
		Community-specific loans (for select areas)	Regional/local loan funds		Community-specific benefits (Tucson)	
		Small business loans	Small business loans		Small business loans	
		High-tech sector loans	Feasibility study grant		Market Assessment Program - feasibility studies for marketing and licensing	Technology development up to \$100K for new products and processes
			Maryland Technology Transfer Fund - up to \$75K for transfers from federal labs or universities		Technology Assessment Program - expert reviews	Technology transfer assistance grant to \$3750; FY09 budget about \$350K
			University Technology Development Fund - up to \$50K to extend research in order to demonstrate a market need			Applied research grants - match for science and engineering transfers
		Working capital loans for incubators of \$15-50K		Arizona job training grant		

Region	Federal	Connecticut	Maryland	Arizona	Arkansas
Indirect measures:	Federal R&D tax credit (1981)	Corporate tax credits - investments in equipment, HR, new facilities; 20% for R&D spent in the state	Tax credits for R&D (3% of basic plus 10% growth expenditures)	Tax credits for R&D (20% up to \$2.5m)	R&D Tax Credit Program - 20% for qualified research programs
		Corporate tax exemptions - manufacturing equipment, upgrades, web costs	Tax credit for investments in biotech firms - 50% up to \$250K	Angel investor tax credit - for investments in rural or bioscience companies	Tax credit for firms that partner with universities and conduct early-stage development and knowledge-based ongoing research
		Urban/Industrial site match of federal tax credit	One Maryland - tax credit for investment in distressed region qualified project	Accelerated depreciation - to encourage capital investment and reduce personal liability	
		Enterprise zone benefits	Enterprise zone benefits	Enterprise zone benefits	Enterprise zone benefits
SME-specific:		Technology extension	Small business preference and reserve programs	Angel tax credit for qualified investments	
		Small business development center	Small business development center - supports applications to SBIR/STTR	Arizona Small Business Connection and Governor's Small Business Executive Council	Small business development center
		Licensing information center - for start-ups		AZ FAST - grant writing help for SBIR/STTR funds	
Strengths / other best practices:	Bayh-Dole act of 1980 allows small co's and unis to keep IP	Clear, transparent resources available online	Emphasis on technology transfer	Arizona Indicators project - to improve transparency, share data	32% growth in GSP from 1998 to 2004 (reflects catching up)
	Support more than 60% of university basic research (though most in life sciences)	Recommendations pending for millions in capital funds for small business and nanotechnology	Monthly and quarterly economic reports easily accessible	Moving Arizona Forward - clear list of goals, strategies and specific actions to boost business, regionalism, R&D	Emphasis on basic research
	US R&D spending is greater than remaining G7 combined	Improvements in the number of STTR awards	Recent rise in industry R&D may signal transfer success	High number of new businesses and IPOs	Reduction of command & control measures
		Creation of new jobs continues as a top priority; Governor is visible supporter	Strong VC investments, especially relative to GSP	1.4 "Inc.500" companies per 10K, scores high in tech concentration and dynamism (clustering)	Tech companies becoming increasingly important
		Emphasis on computer and Internet access	Exceptional Uni system, highly educated workforce, large number of advanced degrees in S&T jobs	Use of tourism and film production to boost brand awareness with business executives, owners	Emphasis on STEM education and Internet access
		Large number of doctoral degrees relative to population	Location near Washington, DC	Increased sales factor for multi-state corporations and decreased business property tax	
Weaknesses:	No actual national innovation policy; programs are ad hoc	Less than average federal or university funded activity to balance and enrich the region	High cost of living, especially relative to only slightly above average earnings	Dependence on too few industries	Research and development plan lacks specific action items
	Top 10 states account for over 60% of R&D	No specific state-sponsored technology transfer grant program	Lack of comprehensive workforce development plan	Lack of venture capital platform	Technology transfer grants comparatively small
	Poor infrastructure in many regions			Somewhat low in human capital investment in the past	Lack of business incentives, low wages, high personal taxation
	Federal R&D investment continues to fall below 1% of GDP				Emphasis on knowledge-based partnerships lacks focus; unclear how Task Force recommendations will be implemented
	Federal R&D share has fallen from high of 65% in 1960s				Last in ranking of R&D inputs; last in number of doctoral engineers
Major players:					
Industry		United Technologies (UTC) Bayer Pfizer Research & Dev GE Aetna UBS	Black & Decker Lockheed Martin Giant Food Stores Home Depot Raytheon	General Dynamics Raytheon Boeing Honeywell Lockheed Martin	Tyson Foods J.B. Hunt Whirlpool Wal-Mart Pilgrim's Pride
Public	National Institutes of Health National Science Foundation National Institute of Standards and Technology Department of Defense Department of Energy NASA Department of Homeland Security Department of Agriculture Department of Health and Human Services Environmental Protection Agency Department of Education Department of Transportation	University of Connecticut - includes 5 campuses, Health Center, Law School, School of Social Work Yale University	University System of Maryland - 11 universities, 2 research institutions, 2 regional centers, 1 office National Institute of Standards and Technology Johns Hopkins University US Naval Academy National Institutes of Health Environmental Maryland Research & Policy Center Maryland Public Policy Institute Calvert Institute for Policy Research Center for International and Security Studies at Maryland Army Research Lab NASA	Arizona State University - links to industry: Avnet, VLSI, Cytec Fiberite, Motorola SATCOM Arizona State University Research Park University of Arizona Arizona Research Center Mayo Clinic	University of Arkansas System - including Medical Center, Cancer Research Center, Walton College of Business National Center for Toxicological Research

Source: Statistics from National Science Foundation 2008 and DeVol & Charuorn 2008

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