RIP-WATCH

ANALYSIS OF THE REGIONAL DIMENSIONS OF INVESTMENT IN RESEARCH

CASE STUDY REGIONAL REPORT: SAXONY (GERMANY)

Authors: Prof. Knut Koschatzky and Dr. Henning Kroll
Fraunhofer Institute for Systems and Innovation Research (ISI)

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ERAWATCH Network asbl: Project management: Logotech S.A., Project team: Fraunhofer Institute for Systems and Innovation Research (ISI)

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Case Study Regional Report on the Regional Dimensions of Investment in Research

OBJECTIVE

The main objective of this regional case study report is to provide a better understanding of the structural and techno-economic characteristics of the European region analysed, to present the key factors conducive to increased investment in R&D and to identify the key R&D policy challenges the region is facing.

BACKGROUND

In partnership with DG Research, the Institute of Prospective Technological Studies of the Joint Research Centre (JRC-IPTS) has been conducting a watching brief on policy developments aimed at promoting both private and public investment in R&D (RIP-WATCH). A stated aim of this policy watch activity is to take stock of developments aimed at increasing investments in R&D in the European regions.

In the design phase of the activity, a typology of the European regions was produced. A balanced mix of regions was selected from each of the nine regional types identified, representing fifteen member states of the European Union.

REGIONS COVERED

Phase 1		Phase 2	
1. Andalusia (ES)	2. Catalonia (ES)	11. Bavaria (DE)	12. Corsica (FR)
3. Carinthia (AT)	4. Crete (EL)	13. Emilia-Romagna (IT)	14. Etelä-Suomi (FI)
5. Dél-Dunántúl (HU)	6. Jihozápad (CZ)	15. Lorraine (FR)	16. Midi-Pyrénées (FR)
7. Norte (PT)	8. Sicily (IT)	17. Saxony (DE)	18. Scotland (UK)
9. Styria (AT)	10. Wielkopolskie (PL)	19. Västsverige (SE)	

THE REPORTS

The regional reports are structured according to the following two interrelated dimensions of regional techno-economic systems:

- **Regional knowledge base**, including the research, technological development and innovation (RTDI) infrastructure, human resources, RTDI efforts and outcomes and knowledge-transmission mechanisms in the region.

- **Regional economic structure**, including the productive structure, regional clusters and networks, international position and financial capacities and instruments.

Each report examines these dimensions from two points of view: their current state, as reflected in a selected set of regional indicators, and their policy context (i.e. policy framework, actors, objectives and instruments).

In addition to the regional case study reports, a **synthesis report** will be produced that combines and interprets the information contained in the case study reports. This will present the strengths and weaknesses of the regions covered and the factors that determined the trajectories of development of their R&D and innovation capacities. It will also discuss the main R&D and innovation challenges identified.

The JRC-IPTS launched the second phase of the activity in December 2006 with the contribution of the ERAWATCH Network. The work was undertaken between December 2006 and May 2007 by a project team led by LOGOTECH S.A. (EL) with the participation of Advansis Ltd, (FI), Faugert & Co Utvärdering AB (SE), Fraunhofer Institute for Systems and Innovation Research (ISI) (DE), Institute for Policy and Practice of Centre on Knowledge, Innovation, Technology and Enterprise (KITE) of University of Newcastle (UK), PREST – Manchester Institute of Innovation Research (UK), and Technopolis France (FR).

The regional case study reports produced in the study are now available on the ERAWATCH web-site at http://cordis.europa.eu/erawatch/index.cfm?fuseaction=intService.home

The synthesis report will also be available on the ERAWATCH web-site.

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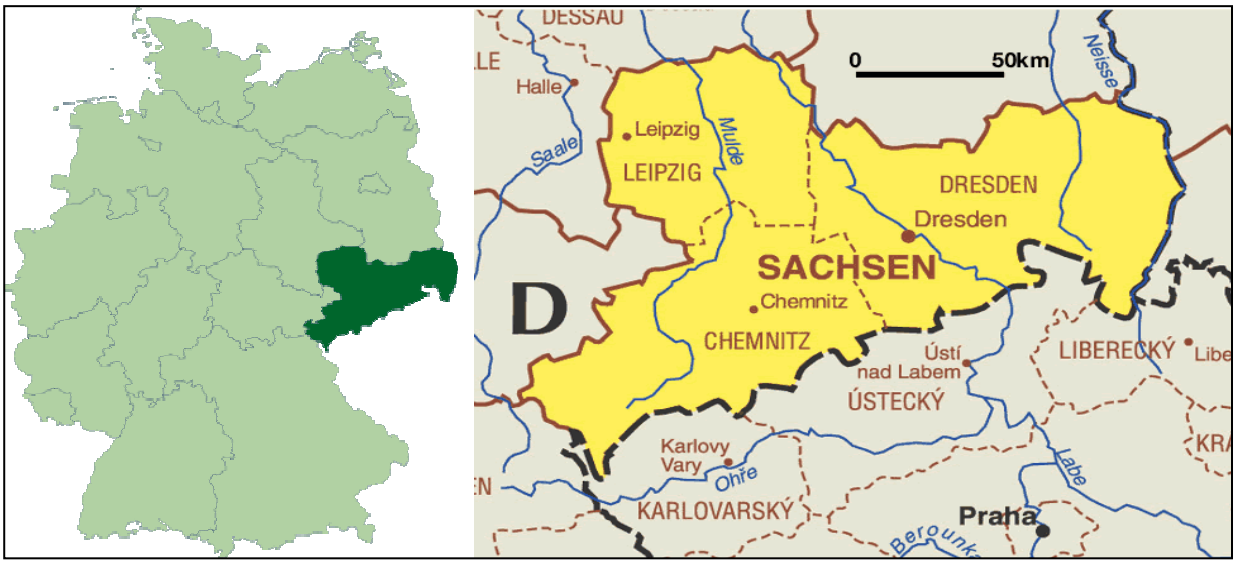
Abbreviations

MC	Management Committee
PM	Project Management
ToR	Terms of Reference
ANBERD	Analytical Business Enterprise Research and Development Database
BERD	Expenditure on R&D in the business enterprise sector
EPO	European Patent Office
FhG	Fraunhofer Gesellschaft
GBAORD	Government budget appropriations or outlays for R&D
GDP	Gross domestic product
GERD	Gross Domestic Expenditure on R&D
GUF	General university funds
HERD	Expenditure on R&D in the higher education sector
HGF	Helmholtz Gemeinschaft
ISIC	International standard industrial classification
IPTS	Institute for Prospective Technological Studies, Seville, Spain
MPG	Max-Planck-Gesellschaft
NACE	Nomenclature générale des Activités économiques dans les Communautés Européennes
N.E.C	Not elsewhere classified
WGL	Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz

1 Introduction

The Free State of Saxony (*Freistaat Sachsen*), in the south-east of Germany (see figure 1), is one of sixteen federal states (*Bundesländer*). With about 4.26 million inhabitants (30/6/2006) it is the sixth most populous state in the country. About 30% of its population live in its three largest cities: Dresden (about 500,000), Leipzig (about 500,000) and Chemnitz (about 250,000).
Saxony is one of Germany's five new states that joined the Federal Republic with German unification in 1990. The centrally planned economy existing at the time had to undergo a process of change leading to a significant re-alignment of industrial activity. Unlike other eastern German states, however, Saxony was able to build on an established industrial base. Although the inherited industrial structure did not permit direct continuity of development, the regional knowledge and human capital base in the region provided a better starting point than elsewhere. Despite significant structural adjustments and job losses in the 1990s, therefore, Saxony has emerged as the strongest driver of economic recovery in eastern Germany over the last ten years (excluding the eastern part of the city state of Berlin).
In 2005 GDP was €85.8 billion. In 2003 Saxony accounted for about 3.9% of German GDP. Regional GDP per capita reached €19,260, which is 73.5% of the German and 88.6% of the EU25 average. Saxony's growth rate has fluctuated between -2.3% in 1997 and 4.1% in 2002. Over this period, the economy grew 14.3%, equivalent to an average annual growth rate of 1.69%. This is largely in line with the development in Germany (12.1%; 1.44%) even though the fluctuations have not taken place in parallel.
Unemployment in Saxony, at 18.7%, is high by German (11.2%) and certainly European (9.0%) standards (2005). Peak unemployment in certain communities is as high as 25%, a figure which is among the 20 worst in the EU25. Most employees work in services (66.2%), while 31.2% work in industry and only 2.6% in agriculture. These figures are fairly close to the national averages (67.8/29.8/2.4%). Trade and business services employment accounts for about 50% of the total.
In relation to regional GDP, enterprises, research institutes and universities in Saxony spend more on R&D than in any other eastern German state, excluding Berlin. With a GERD of 2.21% Saxony ranked seventh among all German states in 2003, just below the national average of 2.52%.

Figure 1: Saxony and its Location within Germany



2 Regional Knowledge Base

2.1 Description of the regional knowledge base

2.1.1 Knowledge creation capacity

Following German unification the Saxon research system had to be reformed, given that the research system run by the GDR government and its industrial combines was full of redundancies and lacked a market orientation. Following unification in 1989/90 it was only possible to find a new role for a small fraction of the existing public research institutes, so that most had to be closed. On the macro level this led to a significant decrease in GERD and the number of R&D personnel employed in the region (see Fig. 8). Nevertheless, concerted efforts by the federal and regional government prompted a rapid recovery that resulted in a 52.5% increase in GERD in the first five years from 1993-1998. After the first structural adjustment was accomplished, GERD growth slowed to a total of 13.9% in the years from 1998-2003 (see Fig. 6, Tab. 1, Tab. 2).

Drivers of Growth in R&D Expenditure

As Table 1 and Figure 6 show, the most immediate rebound occurred in the business enterprise sector. While expenditures for industrial research had literally collapsed in the first years of economic transition they close to doubled from 1993 to 1998 following R&D investment by both local and foreign investors. In the following five years, in contrast, BERD growth (7%, 1998-2003) fell behind the increase in GDP (13% at current prices).

GOVERD, which expanded significantly, has grown more steadily since decisions in the public sector were taken more gradually. As discussed in more detail below, the expansion of GOVERD is based on both the creation of several large new public research institutes in the 1990s and the ensuing substantial expansion of capacities at the existing ones over the course of the early to mid 2000s.

In contrast, HERD has remained comparatively stable although the foundation of some smaller new universities and the modernisation of the established large institutions has prompted an increase that adds up to 31.3% from 1993-2003 (14.4% from 1993-1998). Other than GOVERD, HERD is largely financed by the state government and thus subject to tighter budgetary restrictions that have limited its expansion. Additionally, the need for quantitative expansion in higher education was less urgent than in public research, since most pre-existing facilities survived. Since basic financing for higher education is (at least as far as operating expenses are concerned) almost exclusively provided by the regional level, this can generally equally be said for HERD as long as it cannot explicitly be attributed to federal level third party funding, for example.

Consequently, the relative contribution of the business enterprise sector to regional GERD increased from 38% to 49% during the first five years from 1993 to 1998 whereas it later dropped back to 46% (see Fig. 6, Tab. 1). In contrast, the relative importance of the public research sector has remained relatively constant with 26.1% in 1993 and 27.1% in 2003. HERD, with its below average increase lost relative importance between 1993 and 1998 (35.4% to 26.6%) and has since stabilised (2003: 26.8%). In any event, the high share of HERD in 1993 was a temporary phenomenon that likely resulted from the fact that the higher education system was, at the time, the R&D sector least affected by the economic upheavals.

Development of Employment in R&D

Growth in R&D employment in Saxony has been less dynamic than the increase in expenditure. The years from 1995 to 1999 saw a 10% increase, immediately followed by an 8% decrease from 1999-2003. Most of this trend can be explained by the fluctuation of employment in

the private sector, which rose by 16% in the first four years, but fell by 20% in the following four. By contrast, employment in public research increased steadily by 15% in the first and by 13% in the second four year period. Finally, R&D employment in higher education has remained relatively unchanged (1995-1999: -2% change; 1999-2003: 0% change).

The relative share of employment developed accordingly. While business sector employment rose to 53% from 50% and later dropped back to 46%, employment in public research remained at about 20% until 1999 and only increased to 25% when the business sector lost its momentum. Due to the recent decrease in business sector employment the share of employment in higher education institutions remained relatively stable.

Higher Education Sector

Saxony hosts **seven universities**, seven art academies and **14 universities of applied sciences** (technical colleges, *Fachhochschulen*). **Enrolment** at all higher education institutions reached 107,792 in 2005, of which 77,105 were enrolled at universities. Enrolment in Saxony thus represents about 5% of the German total. Over the last ten years, enrolment has on average risen by about 4.8% annually, resulting in a 60% increase from 1995-2005. In 2005 about 41% of those students were enrolled in science or engineering programmes. The **number of doctorates** awarded in the region has fluctuated somewhat in the last five years and was 1,059 in 2005. Continuously, between 35% and 44% of doctorates are awarded in science and engineering subjects. The **ratio of doctorates awarded to students enrolled** has fluctuated between 1.15% and 0.80% and was 0.98% in 2005.

Altogether, universities in Saxony employ about **13,700 academic staff** of whom about 2,200 are professors. The number of academic staff has continuously grown by, on average, 1.5% a year over the last ten years, while the number of professors has remained largely stable. Despite this increase, however, the ratio of academic staff to students worsened from 0.175 in 1995 to 0.127 in 2005. The ratio of doctorates per professor fluctuated between 0.37 and 0.48, which was also the value for 2005.

Expenditure on Higher Education (which is mostly a responsibility of the federal states) came to €1.93 billion in 2005. Expenditures have risen at an average rate of 3.0% a year over the last ten years. Regional budget planning envisages an expenditure of €735.2 million for higher education institutions in 2007. Even though there is no unambiguous trend in the share of third party funding, it seems to be on the rise. Among the German federal states, universities in Saxony rank fourth in terms of the ratio of institutional to external funding, which in Saxony is 0.28.

According to German **Rankings**, the universities in Saxony remain in the middle of the field concerning relative research excellence (high ranking per department). While they rank fifth in the overall ranking, they rank 8th-10th (identical figures) in the research ranking[1] (CHE 2006a).

Since reunification the university sector in Saxony has seen some new foundations. Examples are the creation of the German-Czech-Polish *International Institute for Higher Education* in Zittau in 1993, the setting up of five new Universities of Applied Sciences in 1992 and the creation of smaller private universities such as the *Dresden International University* (founded on behalf of the public Technical University of Dresden) and the *Deutsche Telekom Fachhochschule* over the course of the 1990s.

Nevertheless, most large universities and technical universities are institutions with long standing traditions that by far predate the socialist era (e.g. University of Leipzig from 1409). The existence of those institutions was therefore hardly questioned in the course of the economic transformation. In the aftermath of unification there was hence less a need for the creation of

[1] The Centre for Higher Education Research (CHE, see www.che.de) regularly draws up a complex ranking for German Institutions of Higher Education based on students assessment, results of studies, international orientation, research, teaching, equipment available, job market orientation and a component evaluation the universities' location. The research assessment is based on the amount third party funding, numbers of publications, patents, PhDs awarded and level of reputation. CHE does not rank individual universities (they are assigned to groups) but regularly publishes a ranking of the German Bundesländer.

entirely new structures than a need for an adaptation of the existing system of higher education to the changed needs of economy and society. Generally, therefore, the development of the Saxon higher education sector in the last ten to twenty years is characterised by structural reorganisation and the transformation of inefficient planned economy institutes into some of the most modern universities in German rather than by the creation of new legal entities.

Public Sector Research

In addition to the higher education institutions Saxony today hosts a strong concentration of **25 public research institutions**. Counting branch offices of public research institutions located in other German states the number rises to 36. In more detail, Saxony is home to six institutes of the *Max Planck Society*[2], four institutes and seven branches of the *Fraunhofer Society*[3] *(FhG)*, one institute of the *Helmholtz Association*[4] *(HGF)*, seven federal institutes and a branch of one institute belonging to the *Leibniz Association*[5] (WGL) and finally ten regional institutes (*Landesforschungseinrichtungen*) (see www.smwa.de).
In early 2002, FhG employed about 950 people in Saxony (14% of national FhG total), MPG employed about 650 people (7%), WGL institutes employed 1.600 people (14%), whereas HGF employed another 650 (3%) (Schmalholz, 2003).
With a view to development trends, the Saxon public research sector has evolved quite differently from the higher education sector. Since there was no equivalent to the large German research associations in the planned economy of the GDR, the public research landscape in Saxony had to be created anew following reunification. More than in other eastern German states, Saxony's public research sector was strengthened by the foundation and later expansion of new institutes. For instance, new MPG institutes were set up successively in 1993, 1994 followed by four new institutes in 1995 and 1997 as well as a major expansion of an existing institute in 2001 (see www.smwk.de). A similar trend can be observed for the creation of new FhG institutes the first five of which were prompted by a Fraunhofer Senate decision in 1990/1991, followed by other new institutes in 1994 and 1998. A similarly important step in terms of the expansion of FhG activities in Saxony has been the establishment of the competence centre for ultra-thin functional layers in the Dresden/Chemnitz region in 1998, which unites university industry and public research institutes under the leadership of the Fraunhofer IWS institute as well as the recent creation of a similar centre for nanotechnology in mid-2005 (FhG CNT, see box below). Arguably, the expansion of FhG institutes has been the development in the public research sector that has made the most important contribution to the im-

[2] The research institutes of the ***Max-Planck-Gesellschaft*** (MPG) perform basic research in the interest of the general public in the natural sciences, life sciences, social sciences, and the humanities. In particular, the Max Planck Society takes up new and innovative research areas that German universities are not in a position to accommodate or deal with adequately. In its 80 institutes it employs 12,000 staff along with 9,000 Ph. D. students, post-docs, guest scientist and researchers.
[3] The ***Fraunhofer-Gesellschaft*** (FhG) operates as a provider of applied-research services in Germany and throughout the world. It is the research organisation with the largest number of applications for patent protection in Germany. The majority of the Fraunhofer Society's activities take place in the middle ground between public sponsorship and free enterprise. It employs 12,500 staff of whom the majority are qualified scientists and engineers, who work with an annual research budget of over €1 billion in 58 institutes.
[4] The ***Helmholtz Gemeinschaft*** (HGF) is a community of scientific-technical and biological-medical research centres. These centres have been commissioned with pursuing long-term research goals on behalf of the state and society. With its 15 research centres, 25,700 employees and an annual budget of approx €2.3 billion the HGF is Germany's largest research institution.
[5] The ***Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz e.V.*** (WGL) is an organisation comprising 84 non-university research institutes that are grouped into five sections covering humanities and education, economic and social sciences, life sciences, physical sciences, and environmental research. Their research is of national significance and thus funded by both the federal and the state governments. The Leibniz Institutes are demand-oriented and interdisciplinary centres of competence that consider themselves co-operation partners for industry, the public administration and government. Other than the relatively centralised MPG, FhG that maintain actual headquarters, the WGL is mostly a coordinating umbrella organisation that also jointly represents institutes in public.

provement of technology transfer from the public to the private sector. Possibly even more important, the establishment of joint competence centres is based on the development of joint activities and has thus directly connected investment in public sector R&D to the expansion of private sector R&D.

In addition to those institutes which are part of the main German public research societies, there are 28 independent institutes that are closely connected with, but legally independent from, universities (*An-Institute*) as well as 4 research centres at the universities of applied sciences. Most of these are active in the field of science and engineering.
As in other eastern German states, several so called "external industrial research organisations" continue to exist at the interface of public research and the business sector in Saxony. These institutes are a result of the transformation process, since they were primarily created and supported during the 1990s as rescue companies to employ researchers laid off by GDR state combines. The idea behind the structure was to avoid an outward migration of researchers until new employment possibilities could be created along the lines of the established German research system (MPG, FhG, WGL etc.) (SMWA, 1992). From an initial total of about 100 units in the early 1990s only 32 have survived, of which of which 12 remain non-profit whereas 20 have been transformed into for-profit R&D service providers. While some of the organisations focus on technology transfer services others resemble SMEs performing R&D to improve their own production activities. In any event, most of them have remained relatively small.
Regional budget planning for 2007 envisages expenditures of €33.0 million for MPG, €3.6 million for FhG, €2.7 million as special contributions to certain FhG Institutes, €54.7 million for the HGF Institute and a total of €60.5 million for institutes of the Leibniz Association. However, regional MPG and WGL funding is matched by equal federal funding whereas in the case of FhG and HGF institutes as much as 90% of funding comes from the federal level. Actual Expenditures for R&D in public research are therefore accordingly higher and are further extended by external funding from business sources. Most FhG institutes, for example, are more than 60% funded from third party sources. According to FhG figures, total income of all regional institutes amounted to €61 million in 2003 (see www.smwk.de) with typical individual budgets for institutes between €10 and €30 million.
In 2003, the total of third party funding acquired by public research institutions in Saxony was €106 million, which allowed them to hire close to 1,500 additional employees. €42 million of these funds came from the business sector, followed by federal, DFG (German Research Foundation), regional and EU FP funding (see www.smwk.de).

The State of Saxony has repeatedly invested in the creation of new public research infrastructure such as the Research Centre for Nanoelectronic Technologies CNT (*Forschungszentrum für Nanoelektronische Technologien*), for the construction of which the state and federal government supplied €80 million in 2004. The CNT is a public-private co-operation between AMD, Qimonda, the Fraunhofer Society, the Federal Ministry of Education and Research and the State of Saxony. An average annual project volume of €34 million was planned for the first five years. Similarly, the Technical University of Dresden and Qimonda have jointly established a Nanoelectronic Materials Laboratory in Dresden (see www.sachsen.de).
Recently, in 2006, the CNT became part of a larger Research Platform Nanotechnology, supplied with funding of €700 million. Again, a significant share of these funds comes as subsidies (€232.5 million). €48 million of this support is sourced from EFRE while the rest is shared between the federal and the regional government.

Business Sector

For the enterprise sector, a 2005 survey (Euronorm, 2005; Euronorm 2006) has found that in Saxony 9,200 people are employed in R&D conducting firms which is about 41% of the total of the eastern German states (not counting former West Berlin). After a recent decline employment has again been rising since 2003.

The share of employment in high- and medium tech industries and in knowledge-intensive business services was 12% in 2005, slightly below the national average of 13.8% which ranks Saxony fifth among the German states (see Eurostat [2007]). Other studies report that a total of 12,000 industrial employees in Saxony conducted R&D in 2004, of whom 56% did so continuously. 7,000 of these employees worked in firms with a workforce of less than 100, and 5,000 in larger units (IAB, 2005).
In 2005, Saxony had 4.5 **business R&D employees per 1,000 workers**, which is above the average for the eastern German states (3.4). However, it is a clear drop from 5.3 in 2001. Even then Saxony ranked clearly below the German average of 7.9 (Euronorm, 2005).
A database created by the technology park and incubator association of Saxony counts a total of **2,340 technology-oriented enterprises in Saxony** (TZS, [2006]). Of Saxony's more than 2,250 industrial enterprises about 450 conduct R&D, about 70% of them continuously. (Euronorm, 2005)
In 2005 **business enterprises in Saxony thus spent €902 million on R&D**, a figure that has increased from around 760 million in 2003. **R&D intensity in the Saxon business sector is 7.5%**, which is the second highest figure in eastern Germany. The turnover of these enterprises amounted to €11.7 billion in 2005. It has been steadily increasing from €10 billion in 2001. In 2005 enterprises conducting R&D in Saxony exported goods and services with a value of €3 billion (Euronorm, 2005).
In 2004 **50% of enterprises in Saxony were innovating**. 32% reported product innovations and 37% process innovations. This is above the western German average, which was not yet the case in 2001. In the industrial sector even 71% of Saxon firms were innovating. 48% reported product, 52% process innovations. Again, this is above the western German average, which was not yet the case in 2001 (IAB, 2005). According to other figures, in 2005 (Penzkofer/Schmalholz, 2006), 55.2% of Saxon enterprises were innovating, employing 63.3% of all employees. This is, however, less than in 2002 when 59.8% were innovating, employing 69.1% of personnel (Schmalholz, 2003).
In 2004 **8% of enterprises reported hurdles to innovation** that were sufficiently large as to prevent innovation – in 2001 only 5% reported such hurdles. The main reasons why firms decided not to innovate were the high cost of investment, high economic risk and problems in raising external capital. Time-consuming administrative procedures (28%) and lack of qualified personnel (20%) were also regularly cited (IAB, 2005).
In 2004 the most regularly cited obstacle to innovation was the lack of own funds (48.0%, in contrast to 23.7% of western German firms) or external capital (35.8%, 18.1%). Lack of willingness to innovate, in contrast, was a less important obstacle than in western Germany, as were legal and administrative hurdles. Similarly, Saxony seems to be well prepared in terms of human capital (4.8%, 15.0%) and availability of co-operation partners (3%, 11%) (IAB, 2005). Other studies confirm that R&D performing companies in eastern German are generally very willing to co-operate in R&D (Euronorm, 2005). Compared to 2001, the availability of capital has worsened (2001: 41.9%/19.5%), whereas the availability of human resources has clearly improved (2001: 21.6%) (Penzkofer/Schmalholz, 2003; IAB, 2005).
In terms of the **results of innovation activity**, according to 2003 data, Saxon firms that continuously performed R&D realised a **higher turnover per employee** (145,000), had **higher export quotas** (45%) and paid **higher wages** (2,190, 2004). However, they did not achieve above average job growth (IAB, 2005).

The development of Saxon business R&D activity from 2000 to 2005 **differs between sectors** (Euronorm, 2005, additionally see Fig. 7)

- R&D expenditure in the chemical sector has been declining from above €50 million in 2000 to €30 million in 2005. The added turnover of the respective enterprises (~€500 million) also decreased, indicating a general downturn in the industry.
- R&D expenditure in the mechanical engineering sector declined from 2000-2002 but in 2005 again reached its year 2000 value of €140 million. The added turnover of the respective enterprises (about €2.3 billion), however, has not completely reached its 2005

level despite a recent increase. According to SMWA publications there are 16 institutions or research groups involved in mechanical engineering R&D and education.

- R&D expenditure in the electrical engineering sector rose sharply from about €100 million in 2000 to more than €500 million in 2005. The added turnover of the respective enterprises did not increase in step, but rose from about €10 billion to €16 billion.
- R&D expenditure in the automotive sector is currently €31 million and is decreasing. The sector's overall turnover is €1.1 billion. According to publications of the SMWA there were 18 institutions or research groups involved in automotive R&D and education in Saxony.
- R&D expenditure in the business services sector fell sharply between 2000 and 2003 but have since recovered to more than €100 million (in 2000 the total was close to €140 million). The added turnover of the respective enterprises has also recovered and risen slightly to more than €400 million after a period of decrease from 2000-2003.
- According to publications by the SMWA there were 19 institutions or research groups involved in biotech R&D in Saxony.

The share of innovators was highest in the banking and insurance sector (72%) followed by the industrial (71%) and the primary sector (61%). In terms of firm size, the share of innovators was highest for enterprises with more than 100 employees (84%), going down to 42% for enterprises with less than five employees (IAB, 2005).
Most of Saxony's 9,209 business R&D employees in 2003 were employed in the manufacture of electrical and optical equipment (2,800, down from 3,062 in 1997), machinery and equipment manufacturing (1,461, down from 2,894 in 1997) and real estate, renting and business activities (2,512, up from 1,130 in 1997) (BMBF, 2006a).
Due to a lack of availability of detailed figures for R&D expenditure and employment in individual enterprises it is difficult to indicate the most prominent performers of R&D beyond the most well known cases listed below. The annex of this report does, however, include a list of large companies in R&D intensive sectors which are likely to be among the major performers of business R&D in Saxony (Tab. 4).

Summary

In total, all actors spent 2.21% of GDP on R&D in 2002. With this **GERD per GDP** Saxony is still some way from the Lisbon target of 3% and ranks 14th among the EU25 NUTS1 regions for which GERD per GDP is known for 2003. Additionally, the Saxon government was and still is finding it a challenge to match the high post-transition GDP growth with a comparable increase in GERD, since in recent years it was not possible to achieve the increase needed to stabilise GERD/GDP by BERD growth alone. When GERD dropped slightly from €1,859 million in 2001 to €1,837 million in 2003, GERD per GDP immediately dropped by 0.2 percentage points.
In terms of **R&D expenditure by sector of activity**, of the total of €1.8 billion in 2003, 46.1% was spent in the business sector, 26.8% in the higher education sector and 27.1% in other public R&D institutions. This profile clearly deviates from the German average (69.7%/16.9%/13.4%) but not as sharply as that of some other eastern German states (e.g. Mecklenburg-Vorpommern, where the figures are 20.8%/38.3%/41.0%). Saxony is the state with the sixth smallest share of business R&D expenditures in Germany.
Since 1995, **employment in the R&D sector** has only increased slightly (0.2% annual average). It has decreased in the business sector (-0.9% annually) and the higher education sector (-0.3% annually). In contrast, there has been significant growth in the public R&D sector (3.3% annually) due to the construction of new facilities and the expansion of existing ones. Overall this represents a total increase of close to 30% in eight years.
In 2004, 9,209 business R&D personnel were employed in Saxony, 3.1% of Germany's total. Saxony also accounted for 6.0% of the total German R&D employment in higher education, with 5,871 R&D employees. Its share of employment in public research institutes was even higher, at 6.8% (5,226 employees), and is constantly increasing (BMBF, 2006a).

In 2004, Saxony accounted for 2.2% of total business R&D expenditures in Germany, totalling €861 million (BMBF, 2006a). Its share of expenditures on higher education in contrast was 5.3%, amounting to €483 million. Even higher was the share of expenditure in public R&D institutes (6.8%, €506 million) (BMBF, 2006a).
In terms of **R&D employment by sector of activity**, out of a total of 20,032 employees (FTE) in 2003, 46.0% were employed in the business sector, 29.0% in the higher education sector and 25.0% in public R&D institutions. This profile clearly deviates from the German average (63.1%/21.3%/15.6%) but not by as much as some other eastern German states (MVP: 22.1%/41.1%/36.9%). Saxony is the state with the eighth smallest share of business R&D employment in Germany.

2.1.1.1 Public Funding

In 2004 the German federal government spent 5.2% of its total R&D expenditure in Saxony (€400 million). In comparison to this, the state of Saxony spent a disproportionately large amount of the regional budget, with 7.8% of the federal total (€619 million). Regional expenditure per capita was highest nationally in 2002, excluding the three city states of Hamburg, Bremen and Berlin (BMBF, 2006a).
The national share of federal government expenditure spent in Saxony has remained comparatively unchanged (about 5%) since 1995 (see Tab. 3). In contrast, Saxony's share of all German states' regional expenditure has increased from 6.2% in 1995 to 7.2% in 1997, peaking at 8.1% in 2001.
Expenditure on higher education and public research as a share of the public budget was highest in Saxony (6.8%), again excluding the city states. This was mostly due to disproportionately large public research expenditure (1.9%) which was highest among all German states. In terms of expenditure on higher education Saxony only ranks tenth (4.9%) (see Eurostat [2007]).
R&D performers in Saxony receive significant funding from a multitude of sources: regional, federal and European. In 2005 alone, one major institution distributed grants of about €76.3 million for various technology support programmes (for policy details see below).
Saxony received around €5 billion of EU structural funding between 2000 and 2006 and will receive another €3.9 billion between 2007 and 2013. Of this, €1.23 billion will be invested to strengthen innovation, science, research and education and €587 million will be invested to strengthen the competitiveness of business enterprises; only €1.2 billion is due to be allocated to the more conventional structural funding task of improving the infrastructure to enable sustainable growth.
Much 'regional' business support that is distributed in Saxony is therefore financed from EU sources. In 2007 subsidies are envisaged for single R&D projects (€43.4 million), for R&D cooperation projects (€43.1 million), technology transfer (€7 million), market access (€2.4 million), networking (€2.7 million), investment in individual enterprises (€72.4 million) and venture capital for technology enterprises (€6.3 million). Similarly, most funding for technology parks and incubators in Saxony is financed from EU structural funding.

2.1.1.2 Output

In 2002 inventors from Saxony registered just over 450 **patents** with the EPO, a rate of about 104 per million population. The three-year average came to 464 over the period 2000-2002. Patenting in Saxony has steadily increased since unification. While before 1989 less than 10 patents were registered annually the figure rose continuously to 136 in 1993, 328 in 1998 and has stabilised around 450-460 since 2000.
25 of the patents registered in 2002 were in IPC section A (human necessities), 132 in section B (performing operations, transporting), 61 in section C (chemistry, metallurgy), 9 in section D (textiles, paper), 11 in section E (fixed constructions), 38 in section F (mechanical engineering), 70 in section G (physics) and 109 in section H (electricity). In terms of patents per population all these values are below the German average, with section B (44%) and section H (53%) closest to the average. About 100 patents were registered for designated high-technology areas, of

which were in 14 in computer technologies, 10 in the biotech segment, 1 in aviation, 10 in communication technologies, 65 in the semiconductor segment and none in laser technologies. In the semiconductor segment the patents/population value is well above German average (276%), whereas registrations in all other segments were well below average (see Eurostat [2007]).
The share of Saxony in total German (~2.5%) and East German (~27.5%) patenting did not fluctuate much between 1992 and 2000 (+- 0.4%, 2.5%) (Dohse, 2004).
Data for **publication activity** cannot easily be disaggregated at the regional level, especially in the case of science. However, based on Web of Science data queries, there is clearly considerable publication activity in Saxony (currently between 7% and 8% of the German total), and publication numbers have been rising since 1993 and only recently (2006) seem to have stabilised between 6,000 and 7,000 SCI publications per year[6].

2.1.2 Knowledge diffusion capacity of the region

To support the transfer of technology from universities, other higher education institutions or public research institutions to the enterprise sector (particularly the SME sector) the state of Saxony maintains a network of **42 centres for technology consulting, technology mediation and support for technology-oriented start-ups** most of which were established in the early to mid 1990s. This network includes: **two patent information centres** at the technical universities TU Chemnitz and TU Dresden, **four centres for technology consulting** (Technologieagenturen), located in Dresden, Leipzig, Chemnitz and Görlitz (which also form the Innovation relay Centre Saxony, which is the EU contact office for the 7th Framework Programme), **14 centres for technology transfer** (typically sector-oriented and often associated with external industrial research associations) and **21 technology parks & incubators** (*Technologie- und Gründerzentren*) (which are often jointly financed by EU funding and local authorities). According to the joint administration of the technology parks these parks have incubated about 650 companies and created about 3,500 extra jobs. Companies in the parks often focus on information technology (36%), production technology (20%) and physics-related and chemical engineering technology (14%). It is therefore likely that their contribution to technology transfer will be largest in those fields.
Additionally there are eight industry-oriented network initiatives in Saxony that could be regarded as R&D related. Three of them are related to larger policy programmes (see below):

- Silicon Saxony
- Biosaxony
- "Nano for Production"

There are also five other networks that may contribute to regional technology transfer:

- Centre of Competence for Space, Aviation and Aeronautics in Saxony and Thuringia
- Network Initiative of Automotive Suppliers in Saxony (AMZ)
- Network Initiative of the Machine and Equipment Manufacturers in Saxony (VEMAS)
- Network Initiative of Technical Textiles Producers
- Network Initiative for Railway Technology in Saxony (BTS)

While some of the initiatives are very recent (e.g. "Nano for Production", started in 2006), others are relatively well established (e.g. Silicon Saxony, started in 2000; AMZ, started in 1999). Generally, however, it may be said that network initiatives have succeeded technology transfer agencies and incubators as the focus of policy attention since around the late 1990s.

[6] The estimate is based on the following query: CI=Leipzig OR CI=Dresden OR CI=Chemnitz OR CI=Freiberg OR CI=Zittau OR CI=Goerlitz OR CI=Mittweida OR CI=Zwickau OR CI=Moritzburg OR CI=Plauen OR CI=Lichtenwalde OR CI=Meissen OR AD=Leipzig OR AD=Dresden OR AD=Chemnitz OR AD=Freiberg OR AD=Zittau OR AD=Goerlitz OR AD=Mittweida OR AD=Zwickau OR AD=Moritzburg OR AD=Plauen OR AD=Lichtenwalde OR AD=Meissen OR PS=Sachsen OR PS=Saxony OR AD=Sachsen OR AD=Saxony

Data on the actual amount of co-operation, technology transfer and spin-off activity in Saxony is scarce. Figures available from individual agencies, however, suggest that consulting activity is vigorous and the agencies do not stand idle (e.g. 100 projects per year in one agency). In contrast, a report suggests that only 90 business spin-offs have so far been realised from enterprises conducting R&D (Euronorm, 2005). A 2006 national report on start-up activity suggests that start-up activity in the technology oriented sectors is below the national average, especially in the high-tech sectors, particularly the IT sector and knowledge-intensive business services. Even among the eastern German states it only ranks second in several sectors (ZEW, 2006).

2.1.3 Knowledge absorption capacity of the region

The ability of the labour force to absorb new knowledge appears to be good, since 62.2% of the 25-64 age group has a **secondary education degree** (ISCED 3-4) in 2005 and another 33.1% has a **tertiary education degree** (ISCED 5-6). ISCED 4 degrees are not very common in Saxony (3%, 2004). The figure for secondary education has slightly declined recently (2002: 65.6%) which may, however, be mostly explained by a corresponding increase in the figure for tertiary education (2002: 28.5%). Earlier there was an opposite short-term trend (1999: 30.3%, 60.4%) so that the mid-term trend should be characterised as stable.
However, the **participation rate in life-long learning** (7.5%) places a question mark over the willingness and capacity to absorb new knowledge, as the rate is not particularly high in European terms (EU27: 9.5%, EU25: 10.1%, EU15: 11.2%) and is even below the German average (7.7%). However, it is remarkable that the participation rate had already gone up by more than two percentage points from 5.5% in 1999 to 8.1% in 2004. Additionally, 3.9% of the economically active population[7] is involved in **vocational training**, and the low figures for life long learning could result from the particular German institutional set-up.
Human resources in science and technology (HRST) as a share of the population (28.2%), however, was above the German average (24.5%) in 2005, as was HRST as a share of the economically active population (53.9%/48.9%).

2.2 Policy context

2.2.1 Governance structure and actors

The German constitution clearly states that some policy tasks are to be performed by federal government while others are to be delegated to the regional level. However, it also envisages that certain tasks -the so called 'joint tasks' (*Gemeinschaftsaufgaben)*- are to be tackled jointly. While many policy fields concerning RTDI investment policies are predominantly the realm of either the federal or regional level, German federalism usually ensures that the other level has a significant voice in the matter.

2.2.1.1 National level

Even though responsibility for many R&D issues is to a large extent decentralised (see below), the German federal government has significant powers and responsibilities in relation to technology policy. The main actor in this regard is the **Federal Ministry for Education and Research** (*Bundesministerium für Bildung und Forschung*, **BMBF**). The BMBF is responsible for the bulk of research and technology support programmes funded at the national level as well as the distribution of the federal share of the funding for higher education and public research. The BMBF has a total budget of €8.54 billion (2005).

[7] This figure was calculated merging data from Regional Statistics (90,558 in vocational training) and Eurostat (2,333,700 economically active population).

Possibly the most important responsibility of the BMBF in terms of the development of RTDI investment in the German regions is that it provides the federal government's share of institutional support for public research facilities. Total support in 2005 came to €2.6 billion, of which €498 million was for institutes of the MPG, €360 million for institutes of the FhG, €1.4 billion for institutes of the HGF and €265 million for institutes of the WGL. Other important shares of the BMBF budget go to federal support for the German Research Foundation (DFG, see below) (€769 million), general innovation support programmes (€326 million) and higher education (€2.2 billion, of which €1 billion is in the form of grants and €925 million is devoted to the construction of higher education facilities). Additionally, the BMBF contributed further specific funding of around €2.2 billion for research.
Finally its role is to launch federal support programmes that can in many cases be applied for by both business enterprises and research institutions from the regions on a competitive basis. While the regional distribution of such competitively distributed funds is usually very difficult to obtain, comparatively recent studies show that BMBF support for business R&D in eastern Germany from the federal level has increased continuously. Whereas in 1998 the ministry supported 368 enterprises in the new states with €1.1 billion in 2004 it already supported 712 enterprises with €1.3 billion (www.bundestag.de/aktuell/hib/2005/2005_182/03.html).

Another main player is the **Federal Ministry of Economics and Technology** (*Bundesministerium für Wirtschaft und Technologie*, **BMWi**), which also co-ordinates and funds some federal support programmes particularly in the field of SME and entrepreneurship/start-up support.

In the 2005 federal budget, BMWi was responsible for energy research (€121 million), aviation research (€58 million) and space research (€1.0 billion envisaged for 2006). Additionally, it contributed a share of the federal funding for the WGL (€43 million). It also covered R&D and innovation support programmes for SMEs (€447 million) and general programmes to support the competitiveness of SMEs (€194 million). Finally, it contributes the federal share of funding to the joint task 'improvement of the regional economic structure' (€694 million), which also partially targets innovation.

Some public research institutes also operate under the auspices of other thematically oriented ministries, most prominently the **Ministry of Defence** (*Bundesverteidigungsministerium*, **BMVg**). Comparing internationally, however, defence research plays a minor role in the German research system. According to the Ministry of Finance, expenditure on defence research stood at approximately €1 billion in 2005.

In addition to the ministries, several foundations coordinate competitive allocation of research funding at the federal level, particularly for basic research: Possibly the most important is the **German Research Foundation** (*Deutsche Forschungsgemeinschaft*, **DFG**) which allocates support for basic research with a total annual volume of €1.4 billion. Another important foundation for basic research is the **Volkswagen Foundation** (*VolkswagenStiftung*), which provides support of up to €100 million a year.

A very important provider of business R&D support from the federal level in Germany is also the **KfW** (*Kreditanstalt für Wiederaufbau*) the main German public bank, which provides credits and guarantees to private enterprises that are eligible for state support (for details see below, regional financial system). Its main departments are the KfW promotional bank, the KfW SME bank, the KfW IPEX-bank and the KfW development bank. The KfW also administers the remaining funds from the ERP (European Recovery Programme). A similar player was the **DtA** (*Deutsche Ausgleichsbank*), another public bank, which was integrated into the KfW SME bank in 2003.

2.2.1.2 Regional level

The German constitution gives the states (*Länder*) considerable say in R&D policy. This is particularly the case for higher education policy, for which responsibility lies almost exclusively at the regional (state) level. In this field, each state independently enacts its own legislative framework. A co-ordination body at the federal level (*Kultusministerkonferenz*) exists, yet without any binding decision-making powers.

Guidelines for public R&D issues, in contrast, are developed jointly by federal (BMBF) and affected regional actors, with a focus on the federal level. Regional governments are often in a lobbying position trying to attract public R&D institutes with a favourable mode of financing (i.e. FhG institutes which are as much as 90% financed from the federal level).

Finally, business R&D support policy is being run in parallel at the federal (BMBF, BMWi) and regional level with regular attempts at co-ordination in commissions, which however, need not come to binding decisions. Co-ordination between the federal and regional level is mostly unidirectional in that the provincial governments react to federal initiatives.

At the regional level, RTDI policy is designed by the **Saxon Ministry of Science and the Fine Arts** (*Sächsisches Staatsministerium für Wissenschaft und Kunst*, SMWK) as well as by the **Saxon State Ministry for Economic Affairs and Labour** (*Sächsisches Staatsministerium für Wirtschaft und Arbeit*, SMWA).

The **SMWK**, the ministry of science, is mostly responsible for issues of higher education and public research i.e. the basic funding of higher education institutions and public research institutes and the development and planning of such facilities (**science policy**) whereas the **SMWA,** the ministry of economy, covers **innovation and technology policy** support measures, with a focus on business sector RTDI development. In contrast to the SMWK which directly decides about capacity building in public research and higher education, the SMWA influences RTDI development indirectly through support programmes and subsidies.

New guidelines for technology policy are regularly designed by a joint working group at the SMWA which unites 25 members from policy, science and the business sector and meets twice a year (Schmalholz, 2005; Riedel/Schmalholz, 2005). Through these meetings, the Saxon government aims to strengthen and institutionalise the continuous co-operation between the two responsible ministries.

While most SMWA measures primarily address the business sector they also support co-operation projects between the public, the higher education and the private sector and are thus also relevant to non-private actors. The volume of regional technology and innovation support provided by the SMWA has increased from an annual €5 million in 1991 to more than €120 million in 2003 and since decreased to around €90-100 million (see www.smwa.de). In the course of the 1990s the focus of support shifted away from public research and particularly external industrial research associations (for which funding that used to constitute more than half of regional support will be phased out in 2008) towards general project and co-operation support for the private sector (Riedel/Schmalholz, 2005, Schmalholz, 2005; budget figures). Overall, the SMWA has spent about €640 million on regional R&D and innovation support of which more the 90% went to single project support and co-operation support. Between 2000 and 2006 funding was awarded to about 1,900 projects (see www.smwa.de).

However, since 1995 most of the funding for technology and innovation support programmes in Saxony is provided by the European Regional Development Fund (ERDF) so that the State of Saxony typically only contributes about 25%. For example, of the approximately €100 million in 2007, only about a quarter will actually be financed from regional sources. Federal funding of regional policy has not played a substantial role in the past, although one-off payments have been made and an annual contribution of €250,000 from the joint task is planned from 2007 onwards.

From 2000-2006 Saxony received over €350 million from ERDF to support R&D (Riedel/Schmalholz, 2005), which Saxon enterprises and public research agencies backed up with an extra €85 million that they acquired for 320 projects supported by the 6th EU Framework Programme for Research.

R&D support financed from the regional budget is typically allocated by the **Development Bank of Saxony** (Sächsische Aufbaubank, SAB) which is the central development agency of the Free State of Saxony acting on behalf of the state. An important sub-institution is the **Saxon Investment Society** (*Sächsische Beteiligungsgesellschaft*).

Public providers of collateral are the **Bürgschaftsbank Sachsen** (BBS), which supported 9,500 projects with guarantees and collateral of €1.5 billion from 1990-2006, and the **Mittel-**

ständische Beteiligungsgesellschaft Sachsen, which supported 800 projects with an investment of €360 million between 1992 and 2006.

2.2.2 Policy objectives

2.2.2.1 National level

Research support policy has a long tradition in Germany and considerable effort has been invested in the field for many decades. When Saxony joined the Federal Republic in 1990, policy emphasis had already shifted away from large scale projects such as were typically favoured in the 1970s. Nevertheless national RTDI policy in the early 1990s had a much broader focus and was less competition-oriented than today.

During the 1990s one major aim of RTDI policy became to stabilise the economy and create innovation potential in the eastern federal states. The late 1990s then saw a shift towards more competition-oriented federal support policy due to an increasing lack of clarity whether the pursued policies actually created additionality. Particularly, the responsible federal actors began to favour 'pilot region' schemes, which sought to test a programme and to establish 'good practice' before it was extended on a larger scale.

Lisbon Objective

Since 2000 one major priority of federal RTDI policy has been to achieve the Lisbon objective of a national average of more than 3% GERD per GDP. As a final step in this direction the federal government has recently initiated the 'High-Tech Strategy for Germany', a comprehensive national strategy document for all its ministries. The government plans to invest an additional €6 billion in R&D during the current legislative period distributed over several-sector specific and general programmes. This represents the largest increase in research funding in the history of the Federal Republic. A total of some €15 billion will be allocated for cutting-edge technology up until 2009. The concrete aim of this re-alignment of national policies is to reach the Lisbon objective by 2010. Besides the traditional major recipients of federal funding – space, energy technologies and IT – the new strategy puts greater emphasis on medical research, transportation technologies, nanotechnologies, biotechnologies, material sciences and environmental technologies. Additionally it aims to strengthen the focus on network support, start-up creation, technology transfer and SME support.

High-Tech-Strategy of the Federal Government

The current national RTDI policy objectives are formulated in the ***"High-Tech-Strategy for Germany"***, which was formed and presented by the German federal government in 2006. With this strategy, for the first time ever, the German government has developed a comprehensive national strategy for all its ministries. All political sectors that affect research and development will be geared towards a clearly defined goal. This strategy puts innovation policy at the centre of government activities. The German government is investing an additional €6 billion in R&D during the current legislative period. A total of some €15 billion will be allocated for cutting-edge technology through the year 2009 (BMBF, 2006a). The policy objectives defined by the federal government are as follows (ERAWATCH Base load, BMWi):

- to attain the 3% goal by 2010
- to promote increased industrial investments in R&D
- to provide additional public funding for key technologies through the "6 Billion Programme"
- to support scientific excellence at universities via the Initiative for Excellence
- to reduce bureaucracy and develop a more innovation friendly environment
- to develop more favourable conditions for venture capital, company creation and innovation in SMEs
- to increase the number of technology oriented and innovative start-ups

- to encourage cross-linking between business and research in order to strengthen regional locations and thematic clusters/networks and to increase national competitiveness
- to support technology transfer from research institutions and universities
- in general, to eliminate restraints on innovation (particularly IPRs and taxes)
- to reform the law for scientists

Two major initiatives that were launched in 2005 and should be mentioned in this context are, on the one hand, the federal **Initiative for Excellence** which distributes €1.9 billion of (mainly federal) funding to institutions of higher education that are selected on a competitive project-oriented basis and the **Pact for Research and Innovation** between the Federal Government and the *Länder* (federal state) Governments which is aimed at raising the basic funding for public research organisations by €150 million or 3% annually.
Both initiatives are part of a larger €6 billion BMBF campaign to create new "impetus for innovation and growth".

2.2.2.2 Regional level

The Saxon government acknowledges that in terms of RTDI development Saxony is in the lead among the German regions undergoing transformation but lagging nationally. The state government is therefore continuously working to upgrade the regional RTDI system. Due to the overall economic situation of the state of Saxony, however, RTDI policy in Saxony is often not driven by RTDI policy rationales alone but very often motivated by the hope that RTDI investment might increase competitiveness and thus alleviate the unemployment problem.

General Orientation and Strategy

In contrast to other German states, however, Saxony has not yet developed a central or comprehensive innovation policy document. Basically, RTDI policy is focused on a set of key technology fields defined in the 1992 "guidelines for technology policy". This agenda-setting in the early 1990s aimed to avoid Saxony's becoming locked into 'follower status' by unduly supporting catch-up investment in profitable but already well-established fields. Instead, the Saxon government decided to focus on nascent technology fields ('future technologies') that still offer potential for Saxony to establish a national position of leadership (SMWA, 1992; SMWA, 2004; Riedel/Schmalholz, 2005): energy technology, material sciences, physical & chemical engineering, biotechnology, microsystem technology, information technology, production technology, environmental technology and medical technology. The respective short term detailed target system and appropriate instruments of regional RTDI policy are regularly discussed and fixed in the operational programmes for EU structural funding (ERDF, ESF).

Sectoral Orientation

On the strategic level regional efforts have been split between direct support for R&D in the key technology fields, supporting regional R&D service providers (external industrial research associations) and support for investments in infrastructure for technology transfer activities.

As mentioned, the Saxon government has continuously sought to pick and actively promote certain fields of technology for a certain time. The usual rationale was to pick emerging fields where it seemed likely that critical mass could later by achieved in Saxony but which would not start to develop without an initial external stimulus. Such comprehensive support usually included activities on the side of science policy (creation of new public research facilities) or to attract major industrial players in the field (for example, in microelectronics) as well as official promotion campaigns and the set of support agencies (see cluster policy below).

Until 1995 the most important priorities were physics-related technology and chemical engineering, microsystem technology, information technology and production technology. In the late nineties support for physics-related and chemical engineering technology increased, followed by biotechnology in 2000, while microsystem technology, information technology and particularly production technology lost importance. However, it is important to note that general inno-

vation support programmes are available independent of the sectoral initiatives currently being pursued. The allocation of funding is generally not predetermined by the SMWA in the form of quotas (i.e. it is not limited to the currently promoted technology fields). In contrast, it is demand-driven and allocation depends on the actual number of successful applications submitted by field (Riedel/Schmalholz, 2005). In fact, the SMWA uses the demand for funding as an indicator whether the current active promotion campaigns still follow the need of the business actors.

Major Initiatives

Since unification, regional RTDI policy in Saxony has been driven by the intention to create (or, from a historical perspective, to re-create) regional innovative potential. It was acknowledged that sufficient momentum for such a transformation of the regional innovation system could neither be created by attracting external investors nor be solely based on existing structures.
It has therefore been the main approach of policy makers to create 'cores of crystallisation' for innovative development i.e. to first establish a strong public research infrastructure and then start cluster initiatives to encourage private investors follow suit. A modified version was to first attract a major investor and then try to talk the firm into locating R&D activities in the region based on generous offers to create an adequate complementary public research infrastructure. Several major initiatives have resulted from this policy concept.

The first step in this direction was the establishment of the Association "**Silicon Saxony e.V.**" with 20 members in 2000. The aim in forming this association was to actively participate in shaping the economic development of the region by trying to regionally anchor the large players that had been attracted (such as AMD and Infineon). The concept envisaged creating a network of public research institutions and regional SMEs that could, on the one hand, qualify as customers, suppliers or R&D co-operation partners for the larger firms and, on the other, serve to upgrade the 'IT image' of the region to influence future investment decisions by the larger players. The association has grown to about 230 members and initiated a lively cluster (see below). Additionally Saxon IT enterprises are organised in the industry association SAX IT (www.sax-it.de) that covers the fields of ICT and new media.

Following a period of concentrated efforts in the IT sector the Land government of Saxony later turned its attention to the biotech-sector. Since 2000 the '**Biotechnology-Offensive Saxony**' has allocated a total budget of around €284 million (including infrastructure investment) to promote the standing, improve the competitiveness and encourage the expansion of the regional biotech sector. The initiative aims at developing existing strengths in the areas of biomedicine, molecular biotechnology, biomaterials and environmental technologies. In Dresden and Leipzig the state subsidised the establishment of 'Biotech Innovation Centres' (*Bioinnovationszentren*, www.bioz-dresden.de, www.bio-city-leipzig.de). These centres house a total of 30 biotech enterprises complemented by six scientific working groups from the respective universities in each centre. Additionally a new Fraunhofer Institute (IZI) has recently been located close to the Bio City Leipzig to strengthen the existing close co-operation between the biotech enterprise sector and local public research institutes.

The most recent initiative by the regional government is the setting up of an innovation cluster '**Nano for Production**' in Dresden based on the co-operation of five FhG-Institutes, two WGL-Institutes, the HGF Institute, the Technical University of Dresden and ten partners from industries. Since the cluster has only been initiated in November 2006, the results remain to be seen. Nevertheless, creating the cluster indicates that the state government continues to move its attention from key technology fields that have gained sufficient momentum to continue as a self-supporting cluster (in this case IT and biotechnology) to those that still face initial uncertainties and need public support.

2.2.3 Policy instruments

Since the early 1990s R&D support for both innovative enterprises and public research institutes in the new German *Länder* has been substantial. On the one hand special programmes were made available for the region while on the other hand nation-wide programmes were addi-

tionally accessible (DIW, 2001). As in the rest of Germany, typical support instruments were direct subsidies, credit schemes with favourable conditions and public guarantees for credits. Innovative enterprises and public R&D institutes could often apply within the same programme for both sector specific (*Fachprogramme of the BMBF*) and non-sector-specific subsidies.

Likewise, funding was allocated to the creation of technology transfer infrastructure such as technology parks and incubators (*Technologie- und Gründerzentren, TGZ*), technology transfer centres, R&D, patent and general IPR consulting.

Particularly in the early to mid 1990s, much public support was supplied by federal institutions (BMWi and BMBF). While federal funding peaked around 1994 and dropped slightly since, regional level funding has been on the increase. Saxony has invested a total of €402 million from 1995-1999, increasing from €125 million to €208 million.

In addition to the direct support, first state backed credits and guarantees were offered by the KfW and the DtA since the early 1990s (*R&D credit-programme for SME, BTU*). Around 1995 the number and development of credit support and guarantee schemes was considerably extended, for example, by support for start-up projects (FUTOUR). More than 90% of all credits approved and equity acquired from 1991-2000 falls within the period 1995-2000. From 1991 to 2000 the KfW approved €612 million of support in all new German states, the DtA contributed €278 million (DIW, 2001).

Development of the Nature of Federal RTDI Support Programmes

Early federal programmes were often relatively broad in nature, i.e. only distinguishing between R&D personnel funding, R&D project funding and funding for co-operation without much further academic elaboration. These initial programmes typically ran from the early to the late 1990s. As a result of a lack of conceptual elaboration some very popular programmes (such as subsidies for the hiring of R&D personnel that were not tied to clearly stated preconditions) were found to be very prone to windfall gains for their beneficiaries and had to be reduced in scope. A more focused approach was therefore taken in the second generation of support schemes, which came into force around 1999. Most programmes are now targeting SMEs (e.g. through **ProInno**) or innovative networks (with **InnoNet**, BMWi and **InnoRegio**, BMBF**)**. Much more than in earlier years funding is now allocated on a competitive basis, to increase additionality and to reduce windfall gains. Saxon enterprises have been applying very actively for federal funding (Kulicke et al., 2005). For example, in 2005 alone, 312 Saxon firms received a total of €31.7 million from the BMBF programme ProInno.

In 2004, 70% of enterprises conducting R&D in eastern Germany had acquired federal support, 44% had acquired regional support while 15% had acquired EU support. In terms of the nature of the programmes, the use of R&D project support still dominated, accounting for 76%, while only 25% took part in co-operation and network support (Euronorm, 2005).

A) Improved innovation and RTD governance

At the national level the main measure to comprehensively improve innovation and RTD governance by co-ordinating and uniting the efforts of different ministries at cabinet level is the High-Tech Strategy mentioned above.

The State Government of Saxony is not tackling the issue with a specific policy plan, but has repeatedly initiated and/or supported comprehensive sectoral initiatives with a 'one-stop shop' agenda such as 'Silicon Saxony' and 'Biosaxony'. In this context inter-ministerial working groups are commonly set up.

B) Creation of an innovation- and entrepreneur-friendly environment

From the national level Saxony is profiting from the technology oriented start-up programmes. These will be assigned total funding of €220 million (nationally) in the context of the High Tech Strategy. While several new measures have been created – such as a **Hightech Start-up Fund** with a volume of €20 million annually (initiated by KfW, BASF, Deutsche Telekom and

Siemens) – other long-existing programmes such as **EXIST (I-III)** and EXIST-Seed (which focus on strengthening the entrepreneurial culture at universities) will be taken under the umbrella.

While no specific policy has been implemented at the regional level, Saxony works consistently to ensure professional and swift handling of administrative procedures related to R&D and innovation and to develop tailor-made solutions for larger enterprises. Surveys seem to confirm that this has been successful (see above).

C) Development of human capital

At the federal level, human capital issues are mostly dealt with in the context of business support measures. Such measures have, for example, been featured in the context of subprogrammes of the national policy line '**Entrepreneurial Regions**' (focusing on eastern Germany), the personnel exchange section of the **ProInno** programme**,** and the **InnoMan** programme**,** which aim to improve management capabilities. Since **DFG funded research projects** in many cases finance PhD studies, they can, in practice, also be regarded as a significant contribution to human capital formation. Similarly, the recent federal competition called **Initiative for Excellence at German Universities** (in which the University of Leipzig is taking part) will indirectly contribute to improved qualification opportunities for young researchers.

From the regional level, less direct support comes for high level qualifications. In the context of business sector support, a programme called "**Assistant for Innovation**", which has been funded with €15 million since 1995 (Riedel/Schmalholz, 2005), enables SMEs to hire qualified personnel for R&D projects and thus indirectly supports the diffusion of the qualifications concerned.

D) Networking co-location and clustering measures

Networking and clustering has become a main feature of many business sector programmes at federal level. This is, for example, the case for the main **'Entrepreneurial Regions'** policy line which includes a programme focusing on 'Innovative Regional Growth Poles' but also for federal programmes such as **ProInno II, NEMO, intec.net** and **InnoNet**. Sector-specific federal support for innovative co-operative projects is provided in the field of software systems and microelectronics.

At the regional level the SMWA runs a substantial **support programme for co-operative R&D projects**, which is one of the largest support measures financed from regional funding. While the total project budget was around €20 million annually throughout the 1990s it has risen to around €30 million annually since 1999 (Riedel/Schmalholz, 2005). Budget figures envisage an allocation of €43 million in 2007. From 1992-2003 600 projects have been supported with a total of €340 million (Riedel/Schmalholz, 2005; SMWA, 2004). Of this support 50% went to large enterprises in 2003 (IfS et al. 2003).

E) Knowledge and technology transfer to enterprises

As regards federal programmes, this issue is to a large degree addressed as a sub-goal within other programmes aiming at networking, clustering and in particular strengthening co-operation between business and the public research sector.

In contrast, the regional government has been very active in this field, establishing **technology parks**, **incubators**, **technology transfer centres**, **IPR consulting centres** and **public-private research enterprises** (external industrial research associations). It has also encouraged the foundation of **independent institutes** associated with universities (*An-Institute*). Until 2004 a total of €54 million had been invested in technology transfer regionally (Riedel/Schmalholz, 2005).

F) Research collaboration of public research organisation with private sector

Like networking and cluster formation, research collaboration between the public and the business sector is a major issue for federal policy makers. In the context of the High-Tech Strategy, €600 million has been assigned to support industry-research relations. Part of this is due to be channelled through the **'Entrepreneurial Regions'** policy line which features two sub-programmes –'**InnoRegio**' and '**Innovation Forums**'– which address such issues. Other relevant instruments are **NEMO**, **intec.net** and the promotion oriented **Networks of Competence,** although this is more a marketing platform than a support strategy. In the context of federal business support programmes there is obviously considerable overlap with network/cluster policy lines as an outcome of increasing focus on innovativeness in the networking field, on the one hand, and the recognition that multi-partner research-industry co-operation often leads to better and more lasting results than isolated research-industry co-operation projects, on the other. In German federal policy, therefore networking and cluster support increasingly implies research/industry collaboration, making it more and more difficult to distinguish between the two fields.

One industry/research co-operation support institution, however, has existed for decades and is thus less clearly oriented towards comprehensive networking – the **joint industrial research** association (*Industrielle Gemeinschaftsforschung, AiF*). At the national level, the AiF distributes around €250 million annually to 100 research labs based on co-operation between 50,000 SME and 700 other research institutions (BMBF, 2006a; AiF, [2007]). Likewise, there has long been a programme (currently named '**FHprofUnd**') supporting joint research by universities of applied sciences (*Fachhochschulen*) and enterprises. In 2006, the programme allocated €1.6 million to Saxon universities of applied sciences, then under the name of "FH3".

On the regional level, the main support for this issue comes from the programme for co-operative R&D project support mentioned above (see D), since most of the supported co-operations include actors from public research or higher education (Riedel/Schmalholz, 2005).

G) Support for public research

As mentioned above, most support for public research in Saxony comes from **institutional funding** to which the regional and the federal level both contribute, to differing extents. Saxon universities acquired an extra €19.7 million from the EU under **FP6**. More significant was **DFG funding,** from which Saxon universities received €142.2 million between 2002 and 2004, equal to 4.4% of the national total, placing Saxony seventh among all the German states (DFG, 2006).

The **sectoral support programmes** in the context of the high-tech strategy may modify research opportunities significantly in the near future. Due to its large number of public research institutes, Saxony is likely to receive a disproportionate share of the funding that will be allocated as top-up funding for public research activities.

The regional level provides two direct forms of support: **regional research support** (based on an independent SMWK support guideline), for which any institution can apply (1-3 million euros a year) and **support for special application-oriented research institutions** (external industrial research associations), which is to be phased out (formerly ~2 million euros annually).

H) Financial R&D measures for the private sector

The federal level offers a broad array of support programmes for innovative enterprises, the largest of them being the **sectoral support programmes** under the high-tech strategy. However, it remains to be decided how much of the €11.9 billion funding will be allocated to private sector support and how much be given as a top-up for public research.

Likewise, Saxony will participate in the increased general **support for innovative SMEs** in the framework of the HTS which will mobilise €1.8 billion for this purpose nationwide. Programmes such as **INNO-WATT** (~€90 million annually), **ProInno** (~€160 million annually) will continue to play an important role under this umbrella. Finally there is one **KfW** support measure that specifically targets innovative enterprises: the **ERP innovation programme**.

At the regional level the SMWA provides general **individual project support** (*Einzelbetriebliche Förderung*) as well as specific support for **telematics**, **eBusiness** and **product design**. Individual project support was introduced in the early 1990s but only became substantial after 1993 when it began to distribute between €10 and €20 million annually. In 1997 it was again significantly increased, to about €30 to €40 million annually (Riedel/Schmalholz, 2005). Since 1992 2,500 projects have been supported, with total support amounting to €750 million in 2004 (SMWA, 2004:149). Even though, in terms of numbers, nearly three quarters of the beneficiary firms were SMEs (SMWA, 2004:232), about half of individual project support was allocated to large enterprises in 2003 (IfS et al. 2003). The 2007 budget envisages €43.4 million for individual project support, plus funding to run projects. In the technology support programmes up to 65% of investments (75% in co-operation projects) are eligible for support (up to a limit) (see www.smwa.de).

Exhibit 1: RTD policy mix affecting the region

Policy Areas	Policy objectives and instruments at National* level affecting the region	Policy objectives and instruments at Regional* level
Improve R&D governance	The High-Tech Strategy of the Federal Government	• (1992 Guidelines for Technology Policy) • biotechnology support (overall €200 million) • microelectronics support (being phased out)
Creation of an innovation friendly environment	start-up programmes in the context of the high-tech strategy (€220 million), e.g. • current federal programme "EXIST" (€35 million annually) • high-tech start-up funds (€20 million annually) • past federal programme "FUTOUR" (€19 million in Saxony)	*no specifically high-tech oriented policy (see other table)*
Development of human capital	• Support for regionalised network initiatives ("Entrepreneurial Regions: InnoProfile, Centres of Innovative Competence") (€500 million 1999-2007) • Subsidies for innovative projects "PRO-INNO" (sub-programme) • Subsidies to improve management capabilities "InnoMan" (€10 million 2000-2004) • DFG project support • Initiative for Excellence at German Universities	• Support to employ an "Assistant for Innovation"
Networking, co-location and clustering measures	• Support for regionalised network initiatives (Entrepreneurial Regions: Innovative Regional	• Regional support for co-operative R&D projects (newly available: €43 million[8],

	Growth Poles) • Subsidies for innovative projects e.g. "PRO-INNO", "NEMO", "intec.net", "InnoNet" (>€160 million annually) • Support for innovative co-operative projects in the field of software systems • Support for innovative co-operative projects in the field of microelectronics	plus support for running projects[8]) • comprehensive initiatives including the setting-up of new cluster institutions (e.g. "Biosaxony", "Silicon Saxony")
Knowledge and technology transfer to enterprises	*Issue is addressed in the context of larger programmes tailored towards networking, clusters and general research-industry relations*	Support for: • technology parks/incubators (*Technologiezentren*) (financed from joint task/EU) • external industrial research associations (~ €2 million, to be phased out) • technology transfer centres, IPR consulting centres (€7.1 million[9])
Research collaboration between public research organisations with private sector	• Support for industry-research relations in the context of the High-Tech strategy (€600 million) • Support for regionalised network initiatives ("Entrepreneurial Regions: InnoRegio, Innovation Forums, InnoProfile") • Subsidies for innovative projects e.g. "NEMO", "intec.net" (€6 million annually) • Support for joint research of industrial enterprises ("AiF", "ZUTECH") • Support for joint research by universities of applied sciences and Enterprises ("FHprofUnd") (€0.5-1.9 million annually) • Public promotion of selected network initiatives ("Networks of Competence")	• Regional support for co-operative R&D projects (newly available: €43 million[10], plus support for running projects) • Comprehensive initiatives (e.g. "Biosaxony", "Silicon Saxony")
Support of public research	• Financed jointly, FhG and HGF mostly financed by federal government (90%), MPG and WGL financed 50:50. • Higher Education predominantly financed at regional level, although federal government significantly contributes to the construction of facilities • EU Framework Programme (€85 million, 2000-2006)	

[8] Budgetary plan for SMWA 2007: section 686 82
[9] Budgetary plan for SMWA 2007: section 686 03
[10] Budgetary plan for SMWA 2007: section 686 02

		• regional research support (€5.6 million in 2004, €15.4 million 2000-2007) • support for non-university, application oriented research institutions (EU financed) (€2.3 million in 2004)

Financial R&D measures for the private sector	• sectoral support in the context of the high-tech strategy (€11.9 billion) • general support for innovative SME in the context of the high-tech strategy (€1.8 billion) • Subsidies for innovative projects, e.g. "PRO-INNO" (~€160 million annually), " INNO-WATT" (~€91.5 million annually) "projects the field of internet" • favourable credit schemes: e.g. "ERP innovation programme"	• SMWA individual project support (newly available: €43 million[11], plus support for running projects) • Support for 'Telematik' (2002→), • Support for 'eBusiness' KOMPRI 2.2 (€5.4 million[12]) • Support for product design • Risk capital for young technology enterprises (€6.3 million[13]) • IPR support (phased out, transferred to IPR consulting centres)

2.3 Conclusions

The Saxon innovation system in its current form is comparatively young. In the course of the economic transformation following German unification the remnants of the former GDR innovation system rapidly collapsed. Changes were particularly dramatic in the industrial sector where most combines could not survive and had to make most of their workforce redundant, including the researchers from their former oversized research departments.
For a period in the early 1990s, therefore, the transition process caused a situation in which the regional industrial sector was unable to employ the human capital it needed in structural terms. As outlined above (see section 2.1.1) the state of Saxony and the federal government reacted by trying to retain the necessary human capital in so called "external industrial research associations". This has been accomplished to a satisfactory degree so that the innovative potential could be re-directed when the industrial enterprises regained the ability to perform –and an interest in performing– substantial industrial R&D in the early to mid 1990s.

Current Characteristics of the System

Despite this growth, R&D spending in Saxony's economy remains below the national average and its knowledge base is characterised by an above average focus on public research and higher education. In contrast, R&D expenditures in the business sector do not yet match those in many other German regions. The lack of application oriented industrial development is also demonstrated by the small number of patent applications.
In contrast, Saxony features relatively well with respect to its human resource base in S&T as well as its pool of R&D personnel, pointing to dormant potentials. Unsurprisingly, however, the

[11] Budgetary plan for SMWA 2007: section 686 01
[12] Budgetary plan for SMWA 2007: section 686 04 and 686 83
[13] Budgetary plan for SMWA 2007: section 892 02

number of R&D personnel employed in the business sector remains below the national average.
In terms of public investment in RTDI facilities, Saxony has received significant attention from the federal government as well as actively initiating and facilitating such investment by means of regional policy making since the beginning of the economic transition in the early 1990s.

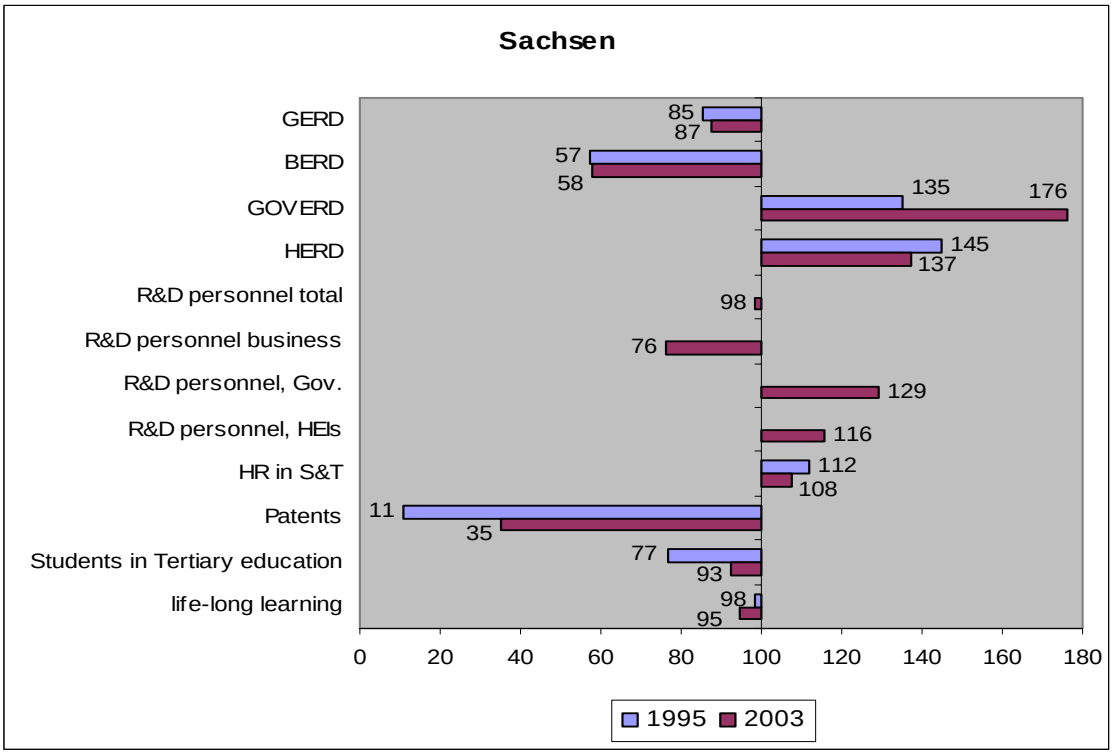
Reasons for the Positive Development Trend

Initially, Saxony's high potential in terms of human capital placed it at an advantage relative to other eastern states, when it came to the actual ability to master the challenges of transition and made it a natural candidate for the expansion of the leading public research organisations MPG and FhG to the German new states in the early to mid 1990s. Since the late 1990s, its re-established and dynamically expanding industrial basis and the resulting ability of local firms to successfully conceive viable innovation projects has put it at an advantage when it comes to obtain federal government subsidies from competitive programme support.
Additionally, the eligibility for federal cross-subsidies and European structural funding ensures the regional government has significant and above average fiscal powers that have in the past been actively translated into considerable regional effort in terms of economic support policies.
In this context, the state government of Saxony deserves credit for making well considered decisions in terms of focusing its investment on RTDI capacity creation so as to kick start development of one selected technology field at a time. Additionally, it has so far not lingered but shifted support to another issue when the previous main project had become self supporting. As discussed earlier, investment to begin private sector cluster development has so far been made in the field of microelectronics (now well established), biotechnology (about to become self supporting) and nanotechnology (still very nascent).

Summary

In summary, Saxony can be regarded as a prime example in terms of targeted public investment in RTDI. The transformation and expansion of the public research system in the course of the mid-to-late 1990s has provided a solid basis and a guiding framework for the development of the high-tech section of the private sector from the late 1990s up to the present. In this respect, the joint centres of competence led by the FhG deserve mentioning. As figure 7 shows, R&D investments in the private sector have risen most in those sectors targeted by public policy and supported by public investments in research facilities.
This development, however, cannot be directly observed from the development trends of the BERD/GOVERD/HERD figures since those are dominated by the internal dynamics of the recovery of business enterprise sector R&D following reunification. To attribute the ensuing slowdown in GERD and employment expansion in the late 1990s to policy failure would therefore miss the point. On the contrary, the Saxon RTDI policy deserves credit for sustaining continuous RTDI after development after the initial post-unification drive subsided.
Nevertheless, the data also show that even large investments in public RTDI such as in Saxony cannot make up for a lack of dynamism in the private sector, which might still occur as it did in Saxony from 2001 to 2003. By contrast, the focus on government expenditures on R&D has increased while the higher education sector appears to have been slightly weakened or outperformed by those of other German regions. The Saxon example thus demonstrates that while public RTDI investment can provide an important basis and crucial guidance for the private sector, it typically does not have the ability to structurally change the RTDI system of a regional economy in terms of the general relation of BERD, GOVERD and HERD.

Graph 1: Comparison of Saxony's knowledge base with that of Germany as a whole



Note: Students in Tertiary education, life-long learning 1999, 2003

3 Regional economic structure

3.1 Description of the economic structure

Before the Second World War, Saxony was more productive and had more people working in industry than the highly industrialised Ruhr region in western Germany, with Dresden-Chemnitz-Leipzig as the economically strongest region.
After the division of Germany into East and West, raw materials extraction and heavy industry were built up, and Saxony accounted for 40% of the GDR's total industrial production. Saxony was a centre for automobile production, printing and publishing, coal mining and power generation as well as chemicals. However, socialist control of the economy meant innovation and investment were neglected and economic competitiveness waned. The change to a market economy which came about with German unification therefore initially led to the collapse of the traditional economic structure. Companies failed en masse, and widespread unemployment resulted, especially in the early 1990s. Business had to undergo a process of fundamental structural transformation.
Today, however, the success brought about by this restructuring process is hard to miss. Since 1991 Saxony has experienced real growth at an annual rate of 3.9% (see www.sachsen.de), so that Saxony's **GDP** came to €85.8 billion in 2005 which was around 3.8% of the German total (compared to a 5.2% regional share of national population). Similarly, GDP per capita (€20,033 in 2005) had risen to 73.6% of the German average and, 2003, 88.6% of the EU25 average. Average monthly net household income rose from €843 in 1991 to €1,503 in 2003, equivalent to a 78% increase (see www.sachsen.de).
GDP Growth has not been limited to the first years after reunification but has remained high in recent years and is predicted to remain so (around 2%, with the exception of 0.5% in 2000, close to 0 in 2005 and 1.5% envisaged for 2007) (Berlemann et al., 2006). The main driver of growth is the industrial sector, which grew at an average rate of above 10% annually in the 1990s and kept growing at above 5% in the early 2000s. Saxony's share of national industrial production has thus risen from around 1% in 1991 to above 3% in 2003 (SMWA, 2004:221).
Following reunification, Saxony, like all eastern German states, was struggling with outdated industrial technology, a lack of market orientation and a lack of competitiveness. This initially resulted in an economic collapse leading to a major unemployment problem previously unknown in the area. Subsequently, the years from 1991 to 1996 saw a strong recovery driven jointly by continuous above average investment in industry, the service sector and the construction industry that resulted in a doubling of regional GDP (see Fig 9, Fig. 15). Investment rates in Saxony remained above the national mean until the year 2000 (see Fig. 15). In the years following 1996, however, investment per employee significantly decreased and growth slowed, not to pick up again until around the year 2000 (see Fig. 9). Interestingly, however, while investment per employee has generally fallen since 1996 it has been rising in the industrial sector (see Fig. 15) – possibly indicating a shift from public sector to government sector driven development, even though the trend is less apparent for investment per GDP.
Likewise, labour productivity in Saxony doubled from a very low base between 1991 and 1994 with growth slowing after 1996 and picking up again around the year 2000 (see Fig. 10). Other than GDP growth, which is jointly driven by manufacturing and the service sector (construction being in decline since 1996), productivity growth is almost exclusively based on developments in the manufacturing sector, where productivity has more than quadrupled since the early 1990s (see Fig. 11).

3.1.1 The characteristics of the productive structure of region's economy

Sectoral Structure

The **basic sectoral structure** mirrors the German average, with a very low share of agricultural employment (2.6%), a higher share of industrial employment (31.2%) and the largest share of employment in services (66.2%). About half of this employment is concentrated in trade, repairs, communication and the banking sector (47%), while the other half (53%) is in public ad-

ministration (2005). No NACE section (except construction) played a disproportionately important role nationally.
In terms of **value added** 1% was in the agricultural sector, 29% in the industrial sector (including construction), 16.0% in trade, repairs and communication, 27% in banking and another 27% in public administration (2004/2005).
While Saxony had high –above national average– **investment rates** during the 1990s, in common with the other eastern German states (reaching more than double the national average in the early 1990s) – the disparities have evened out since around 2000. Obviously, much of this early investment was driven by the demand created in the economic recovery in the early 1990s. Likewise, the state of Saxony continuously featured one of the highest figures of **investment per employee** in Germany. Since it peaked in 1996, however, gross fixed investment per employee has continuously dropped and in 2004 was below the national average (98%, see Fig. 15).
In 2005, the Saxon industrial sector (including mining) comprised 2,927 firms and employed 230,000 people. Turnover was €44.6 billion of which €13.7 billion was generated by exports (see regional statistics).
The **traditional branches** in Saxony are the vehicle engineering industry (turnover of €5.8 billion and 27,000 employees in 2004), mechanical engineering (turnover of €5.0 billion and 34,000 employees) and metal processing (turnover of €5.1 billion and 36,000 employees). A rising field is electro-technology, electronics and microelectronics (turnover of €5.8 billion) and, at a nascent stage, biotechnology (see www.smwa.de). Other important fields are food processing (turnover of €6.2 billion and 24,000 employees), paper publishing and printing as well as the traditional energy and mining sectors (Deutscher Bundestag, 2005). The sectoral structure of the Saxon Economy is thus characterised by a comparatively high share of firms in low value-added sectors (IAB, 2005).
Figures on employment demonstrate that the relative importance of high-tech production and knowledge-intensive business services has risen – in particular since the late 1990s (see Fig. 13, Fig. 14). While early post-unification recovery development was mostly driven by medium and low-tech industries as well as the construction sector, new development trends are more strongly based on high-tech and medium-high-tech development. The share of these activities in total manufacturing employment has risen by 26% from 44% in 1995 to 55% in 2006. Most starkly the relative share of employment in high-tech manufacturing has jumped from 6% to 11% of all manufacturing employment from 1995-2006.

Key Players

A list of Saxony's largest companies (by turnover and employment) in key industries (automotive, machine building, chemical, microelectronics, pharmaceutical, and biotech) is included in the Annex 3. In terms of location, the automotive sector is concentrated around Chemnitz, Zwickau and Dresden; the chemical industry consists of large installations outside the agglomerations; the pharmaceutical and the microelectronics sector centre on Dresden, and biotech companies can be found in both Dresden and Leipzig. Machine manufacturing companies, in contrast, are relatively evenly distributed across the region (see Tab. 4).

Size Distribution of Firms in the Business Enterprises

The Saxon **business sector is characterised by an above average share of SMEs**. In 2004, tax statistics suggested that there were 125,128 firms with a turnover of less than €1 million, 10,730 firms with a turnover between €1 and €50 million and only 126 with a turnover of more than €50 million. Thus, whereas the share of small enterprises is slightly higher than the German average, their share of total turnover is significantly higher (68.9%/39.8%). The same is true of the share of employment in companies with less than 500 employees (86.0%/78.7%). The share of SMEs is particularly high in real estate, trade and industry. However, the total turnover accounted for by SMEs has declined continuously since 1996, so that their share has dropped from above 80% to less than 70% (SMWA, 2006c).

In Saxony SMEs account for a large number of firms in **industry** as well as in the services. In late 2005 1,707 enterprises with less than 50 employees accounted for 20% of employment and 10.8% of turnover, 659 enterprises had 50-99 employees (19.7%, 14.0%), 424 100-249 (27.5%, 21.4%), 93 250-499 (13.3%, 18.7%), 36 500-999 (10.4%, 14.8%) and only 8 more than 1,000 employees (9.2%, 20.4%) (see regional statistics). So, while the large companies certainly make an important contribution, it is SMEs that account for half of turnover (46%, German average 2004, 29.2%) and more than two thirds of employment (67%, German average 2004, 46.3%) in Saxony.

Productivity

Labour Productivity per capita in Saxony (GDP/workforce) rose to €45,500 in 2005. Even so, it only reached 78.6% of German average, and is at a level of about 60% of that of the most productive state. Since 2000 labour productivity has grown around 50% from €32,250 in 2000 (SMWA, 2004:256). Measured in terms of GDP/working hour, productivity in Saxony rose by 24.8% between 1998 and 2005 and reached €30.41, which is 75.3% of national average and about 60% of that of the most productive state. Recent annual increases are still well above the national average, although growth rates peaked in 2002 and have since fallen (see www.smwa.de).

Turnover per capita in Saxony was below the national average in all sectors. In industry it stood at €118,000 (59% of national average), and in the service sector it was €61,000 (58% of the national average). Equally, value added per capita was below the national average in all sectors. In industry it came to €48,000 (63% of the national average), in the service sector it was €37,000 (56% of national average) (IAB, 2005). Turnover per capita of Saxon Enterprises continually conducting R&D was about €160,000 in 2005 and thus clearly below the eastern German average (Euronorm, 2005). Due to recent green-field construction of modern production facilities, the automotive sector is the most productive sector in the region. Turnover per employee in Saxony is as high as €360,000, 17% above German average.

Labour Market

The **quota of self employed business people** as reached 11.3%, which is more than twice as high as in 1991 (4.6%), close to one third more than in 1998 (8.7%). It is the highest value among the new German states and has reached national but remains far below EU average (see www.smwa.de). While there were only 1,400 net start-ups in Saxony in 2001, in 2004 net start-up activity peaked at 10,500 and fell again to 3,800 in 2005. Part of the effect in 2004 may be due to labour market policies encouraging the unemployed to start a business.

Unemployment in Saxony peaked at 18.7% in 2005 (see Eurostat [2007]) although with the recent upturn in the economy it has dropped to 15.4% (see www.arbeitsagentur.de). Nevertheless, it remains far above national average (9.6%). Before the recent increase, GDP growth had not translated into employment. With the exception of stable periods from 1999-2000 and 2003-2004, employment has dropped by around 1% annually. From mid 1999 to mid 2006 the number of employees registered for social security in Saxony has dropped by 15%, in line with the general trend in eastern Germany (Berlemann et al., 2006).

3.1.2 Systemic characteristics of the region

According to a 2004 survey in Saxony, the share of companies engaged in co-operation in Saxony has risen from 88% in 1999 to 93% in 2003, which is especially due to an increase in co-operation of medium sized companies 50-250 (88%-100%), while the share of large companies sunk from 100% to 88% > 250. Co-operation is particularly on the increase in training (46%/63%) and R&D (2001/2003: horizontal 20%/34%, vertical 59%/69%) (Ossenkopf et al., 2004).

Another report suggests that Saxon enterprises conducting R&D have an above average propensity to co-operate with partners from the region (49%, Euronorm, 2005).

According to official sources (see www.sachsen.de, www.smwa.de) Saxony features five major clusters (lagging and declining sectors were deliberately omitted):

- Microelectronics (in the area of Dresden) [22,000 employees],
- Biotechnology (in the area of Dresden and Leipzig),
- Mechanical Engineering (in the area of Chemnitz),
- Automotive (in the area of Zwickau and Leipzig) [60,000 employees],
- Microsystems (in the area of Mittelsachsen).

The most relevant clusters at the moment in terms of policy assessment are the information technology and the biotechnology cluster. Other clusters such as automotive and mechanical engineering certainly exist but are either on the decline or less policy driven.
Main players in the field of microelectronics are large corporations such as Infineon (Dresden), AMD (Dresden), Freiberger Compound Materials (Freiberg) and Wacker Siltronic AG (Freiberg). In 2002 the **Saxon IT cluster** was constituted by 760 Firms with over 20,000 employees. At the same time estimates suggested that a total of €6.9 million had been invested in the IT sector in Saxony. 118 firms of the 760 produced basic devices and equipment, 437 were software developers and software service providers while 142 were producing applied microelectronic devices. Newer figures suggest that the Saxon IT cluster currently comprises 1,500 firms with 43,000 employees, of which 200 firms (with 20,000 employees) deal with microelectronics in a narrower sense (WfS, 2006d).
About 230 enterprises with an turnover of €3 billion and an employment of 17,000 are members of the Association "**Silicon Saxony e.V.**" (www.silicon-saxony.net), founded only with 20 members in 2000. The association aims to concentrate relevant information and existing expertise, to communicate and exchange information about partnerships, to establish co-operative ventures between companies and research institutes and associations in national networks, to create syndicates and to actively participate in shaping the economic development of the region. 34% of the members of Silicon Saxony were active in the field of semiconductors, 18% produced equipment, 11% manufactured electronic devices and 37% produced applications for specific purposes (www.invest-in-saxony.de). IT enterprises are also organised in the industry association SAX IT (www.sax-it.de), which covers the fields of ICT and new media.
The Saxon **biotechnology cluster** comprises 62 core biotechnology companies and life sciences equipment manufacturers, 6 pharmaceutical companies, along with 70 service providers, distributors, and support companies offering financial or other consultancy. Overall these companies employ 5,700 people and their turnover totals €670 million. Additionally, earlier studies mention 50 companies producing instrumentation. Saxony is the only biotechnology cluster in Germany that has grown continuously over the last six years. A service provider has been established for biotech enterprises under the name of **Biosaxony** (www.biosaxony.de, see www.smwa.de) in 2005. Biosaxony offers consulting for investors and 'information from a single source'. The association also co-ordinates Saxon biotechnology activities on behalf of the SMWA. However, an active network in the sense of Silicon Saxony remains to be established.

3.1.3 The regional economy in the international context

Increased **export activity** has contributed substantially to the rapid growth of business, and particularly industry, in Saxony. With over €10 billion of goods and services Saxony exported more in the first nine months of 2001 than in the entire previous year. Saxony is thus the only state in the former East Germany which has been able to steadily increase its level of exports since 1991. The main destination for Saxony's exports is the USA, where nearly a fifth of all goods are sent, followed by Great Britain, France and Italy (see www.smwa.de).
Imports rose from €2.1 billion in 1991 to €10.8 billion in 2005, while exports increased from €2.6 billion to €17.5 billion. The trade balance, which had become slightly negative in the mid nineties, is now continuously improving. €11.4 billion of Saxony’s Exports went to Europe and €2.9 billion to America and Asia (see Fig. 12, www.smwa.de).

In 2002 Exports from Saxony were mostly technology intensive 58.7% (€7.8 billion), a figure that had gone up from 31.6% (€1.1 billion) in 1995. Similarly, imports were oriented towards technology-intensive goods (43.8%, €3.1 billion). Saxony thus has a positive RCA value for technology intensive goods (0.29), while values for capital and labour intensive goods are negative (-0.44, -0.85) (Votteler, 2003). The most important export goods were cars and car accessories, followed by electrical engineering products and paper-making and printing machinery.
Manufacturing industry accounted for 31% of Saxony's exports in 2005, 75.6% of German average (see www.bmwi.de). This had risen from 27%, in 2003 and 18% in 1995. However, the export quota of Saxon enterprises was 9% in 2003, above eastern German (7%), but clearly below the western German average (17%) (IAB, 2005).
Foreign direct investment amounted to €1.4 billion directly and €330 million additional in 2003, down from €1.8 billion and €250 million in 2002, and €1.4 billion and €210 million in 2001 (Deutsche Bundesbank, 2005; Deutsche Bundesbank, 2004).
In 2003 the owners of 86% of all enterprises in Saxony were from eastern Germany, 7% of firms had owners from western Germany and only 3% had owners from abroad. However, enterprises whose owners were from eastern Germany accounted for only 43% of total turnover, firm with owners from western Germany accounting for 37% and foreign-owned firms for 10%. Turnover per employee was highest for foreign owned firms at €197,000, followed by €182,000 for enterprises from western German and only €80,000 for firms with owners from eastern Germany (IAB, 2005). Enterprises owned by owners from western Germany and abroad are drivers of change and, due to their superior market access, tend to be larger and have higher productivity.

3.1.4 The local financial market

In Saxony, as in the whole of Germany, the local financial system is dominated by the public savings banks (*Sparkassen*) and their umbrella organisations, the regional banks (*Landesbanken*) owned by German regions. Nevertheless, branches of all large private banks are present regionally.
In Germany the **public savings banks** are traditionally the prime lenders to SMEs, which are unattractive to most private banks. The reason for this is that a savings bank normally only covers one community. Therefore it is typically familiar with the local businesses and can thus better assess their creditworthiness than external players. Additionally, the statutes of the savings banks are not oriented towards profit maximisation but implicitly towards regional development which permits them to offer small volume lending under better conditions than the private banks. Finally, an inter-regional joint liability system (*Sparkassen Finanzgruppe*) enables the small and locally based institutes to take risks they would otherwise not be able to. Even though this system has recently been criticised by the European Union institutions concerned, and it is questionable whether it will persist in its old form, it has driven development in Saxony from reunification to the present.
Besides providing credit and loans at local market conditions, the banks (again often the savings banks) administer most public financial support schemes. They hand out subsidised credit to individual applicants and are reimbursed by the project executing organisation at federal or regional level.
The source of such public financial support programmes in the form of loans, mezzanine financing, equity capital and consulting services is typically the *KfW Bankengruppe*. Within this banking group *KfW Mittelstandsbank (KfW SME bank*) offers promotional loan financing covering operating costs for business founders, self-employed professionals and established companies. It offers support to a wide range of enterprises.
The investment projects are usually tied to a specific purpose and financed under favourable terms and conditions. Typically, certain conditions have to be fulfilled by the enterprises in order to qualify for one of the programmes.

Financing of Innovation

This system appears to be less freely and easily accessible than Saxon enterprises would like, as according to a survey, 70% of innovating enterprises in Saxony finance innovation exclusively from internal sources, whereas only 2% are able to rely exclusively on external sources. The share of enterprises depending on internal sources is thus higher than in Germany as a whole (58%) and even the eastern German states (65%). According to the same survey 11% of Saxon innovators in the business sector found it difficult to acquire external capital which for 9% had an impact on their innovative activity. Moreover, studies suggest that the availability of external capital may have worsened, rather than improved (IAB, 2005).
Support for this assumption can be found when looking at the number and volume of venture capital contracts signed in Saxony between 1994 and 2005. According to the German Private Equity and Venture Capital Association, there are three public and no private venture capital firms in Saxony (see www.bvk-ev.de). While the number of VC recipients had increased from 40 in 1995 to 140 in 2000, it has since dropped back to 40. Saxony's share of VC recipients in Germany has declined more or less continuously from 10% in 1996 to 5% in 2005. The volume of approved VC in Saxony has progressed similarly with an increase from €20 million in 1995 to €160 million followed by a drop back to €40 million in 2005. Saxony's relative share of total German VC has dropped from 5.5% in 1996 to 4.3% in 2000 and 1.8% in 2005. These figures indicate that other regions with a larger number of regional VC providers have developed more dynamically both during and in the aftermath of the 2000 VC boom (e.g. Baden-Württemberg, 13.1% of total investment in 2000, 21.4 in 2005; Berlin, 11.4% in 2000, 15.9% in 2005). A slow but not substantial recovery has been visible since 2003. In short, it is clear that Saxony continues to lag behind the rest of the country in terms of VC, and rather than improving its relative standing is continuously losing ground. This lack of dynamism is likely to be mainly due to the absence of local VC providers, although another reason could be the readily available public support for different kinds of RTDI projects that certainly reduces the demand for private VC, which is typically both more expensive and entails a greater loss of entrepreneurial autonomy.

3.2 Policy context

3.2.1 Policy objectives

3.2.1.1 National Level

One of the most urgent issues for German (socio-) economic policy is the high level of unemployment in the eastern German states resulting from the job losses following in the wake of the collapse of the planned economy in the early 1990s. Until today, no successful approach has been found to address this problem. Since few of the old firms survived the competitive pressures of the economic transformation, industrial renewal had to be largely based on setting up new subsidiary production sites or creating entirely new enterprises.

General Development Trends in Policy Design from the early 1990s to Today

Since the seriousness of the economic situation in the former GDR had not been sufficiently foreseen, the federal government was to some degree caught unaware and took some time to adequately react and devise targeted strategies. The very early 1990s therefore saw a lot of quick-fix and large-scale approaches motivated by the sole aim to somehow mitigate the unexpectedly serious effects of economic transformation.
Since the main objective was to reduce unemployment, generous subsidies were offered to all enterprises willing to locate in the eastern states, largely irrespective of their sectoral orientation or technology intensity. Additionally, significant support was provided to those remaining companies of a GDR background that had managed to survive the early phase of transformation but needed resources for strategic investment.
After several reports revealing questionable additionality in many cases and even that job losses could not always be sustainably prevented (see Koschatzky/Lo, 2005) a public debate around the danger of creating a "subsidy-based mindset" arose. As a consequence, support measures were revised and focused more on supporting the evolution of sustainable economic

structures in the region as a whole based on networks, co-operation and technological upgrading. Additionally, the emphasis shifted from large scale support for individual factory sites to support programmes for the SME sector, with funding being allocated on a competitive basis.
However, while innovativeness and competitiveness in the industrial sector are often cited as the reasons for national initiatives in the eastern German states, it is important to note that, ultimately, these measures are still as often about the creation of research capacities in lagging regions or the stabilisation of still nascent innovative potentials (to prevent further job losses) as they are about the proclaimed aim of building on strengths.
Since, after a period of convergence during the early and mid 1990s, the disparities between the eastern and the western states have again increased since the late 1990s, any large scale investment in the eastern states is still welcome and is likely to attract significant public support. Overall, however, the federal government now pays considerable attention to ensuring its policies are focused. Drawing on experience from the 1990s, federal institutions have also become more knowledgeable about picking those investors for large-scale support that are likely to constitute a core around which a future agglomeration of business sector activity may crystallise. A term commonly used in this used in this context is to create "motors for development".

Trends in Policy Concerning the Legal Framework for the Business Sector

Another long-term issue is the question of how public administration could be streamlined and unnecessary regulation be either avoided or even abolished. After little progress had been made in this area during the 1990s the new federal government in office since 2005 has recently launched the "*Mittelstandsentlastungsgesetz*" (law to lighten the burden of bureaucracy on SMEs). If successful this initiative may free up resources enabling innovative activities to be undertaken.

Trends in Higher Education Policy

In the field of higher education, Saxony has been one of the prime targets of national policy in the 1990s aimed at supporting the adaptation the socialist higher education structures to the needs of a market economy and the education system of a democratic state. This transformation, however, is now largely complete. Today, higher education policy is to a large degree regionally driven, as it is in all German states. However, the number of national initiatives and competitions to improve the quality of higher education is on the rise and may result in future opportunities (and possibly threats) to the Saxon higher education system.

Trends in the Systems of National and European Cross-Subsidisation

On a more indirect level, but possibly more importantly, is the development of the national system of budgetary cross-subsidies without which no eastern German state could implement RTDI support measures to the extent Saxony does. Currently, Saxony's public investment quota of 24.2% (2006) is the highest in the country and more than doubles that of comparable western German states. Recent legislation, however, determines that annual transfers are to be reduced in the future and will ultimately be phased out around 2020. Nonetheless, substantial changes may still not occur for some time since, whereas during the 1990s much of the financial means were (and legally had to be) invested in the creation and refurbishment of the outdated GDR infrastructure, the state governments are now free to decide the allocation of a much larger share of the transferred funds than previously (before 2002). Over the next few years, therefore, the state governments will possibly retain their capacities to implement RTDI policies to the extent known from previous years.
The same reasoning applies to EU structural funding, which is one of the major sources for business sector RTDI support implemented by the regional government. While the total amount of funding available has slightly decreased as a result of EU enlargement, the new guidelines on the allocation of funds to Lisbon related objectives might actually lead to an increase in RTDI related spending from this source in the future.
In general, as the Federation of German Industries states in a recent paper, the economic policy relevant for the eastern German states is more and more the general national policy framework rather than measures specifically directed at improving the economic situation in eastern German regions.

3.2.1.2 Regional Level

In the years immediately after unification Saxon economic policy focused on **political initiatives to attract large investors** (*Ansiedlungspolitik*) to improve the economic basis of the region. Out of a total of 5,500 businesses that were set up in Saxony before 2004, 800 were supported by the Saxon business development agency, among them 16 international investments that created a total of 6,600 jobs (SMWA 2004:139). The means used to achieve this aim were investment support programmes, credit guarantee schemes, R&D support programmes and support programmes for qualification and employment. In the early years the State government focused on tailor-made solutions for large employers, to tackle employment problems, raise regional productivity and improve the overly SME-centred economic structure of the region. On several occasions the state government has paid for a large share of the investment.
However, the regional government was very successful in developing substantial '**tailor-made subsidy solutions**' for potential large-scale investors. Many of these large firms attracted in the 1990s constitute the core of today's clusters. A recent study commissioned by the state government suggested that the total of €1.2 billion subsidies from 1994 to today would result in a €1.9 billion increase in tax income and additionally supply the social security systems with more than €3.9 billion (see www.sachsenlb.de).

AMD (American Micro Devices) has been investing in Saxony since 1996, starting large-scale production in 1999. The cumulative investment since 1996 totals €3 billion and 3,000 jobs have been created. According to news reports, AMD aims to invest another €3.4 billion by 2009. The modern production facilities 'AMD Fab 30' and 'AMD Fab 36' are internationally competitive and supported by a design centre (Dresden Design Center). However, of the €2.4 billion investment in 'Fab 36' only €900 million was contributed by AMD – €545 million came as non-refundable subsidies from regional, federal as well as from EU sources while another €700 million in loans was 80% secured by government guarantees (see www.sachsenlb.de, tagesspiegel).

ZMD, the former GDR chip producer, only avoided bankruptcy with the help of €21 million European structural funding in the late nineties. This, however, may not have been legal. In 2003 ZMD achieved a turnover of €80 million, employed 630 people and had just invested €100 million in a new development centre (ZMD-Campus) (see www.sachsenlb.de).

In recent years, however, policy makers have realised that structural deficits in the regional economic structure cannot simply be overcome by green-field investment but have to involve the existing economic actors. The policy focus has therefore shifted towards **supporting SMEs and networking**. For example, the SMWA has initiated several co-operation initiatives (*Verbundinitiativen*), a network project support programme (*Verbundprojektförderung*), started a competition for networks of human resources (*Ideenwettbewerb Fachkräftenetzwerke*) and extended the State Government's co-operation support programme (SME support, subprogramme 5). A comparable EU Joint Initiative (*Interreg IIIa*) ended in 2006.
According to a 2004 study, the quota of public subsidies for investments in enterprises in Saxony is highest among all eastern German states at 34%, complemented by 49% of internal funding and only 16% of external credit. The western German figure, in contrast, was only 8% but 26% for external credit and 66% for internal funding, which points to a better availability of external capital and a better stock of own resources. Subsidies are most important for enterprises with more than 100 employees (39%) and become less and less important the smaller the enterprise becomes (20-99: 29%, 5-19: 25%, 1-4: 19%) (IAB, 2005). Subsidies are particularly high in the service sector where they account for 40% of all investments (22% for business services). Nevertheless, at 17%, the share accounted for by industry is also high in Saxony (IAB, 2005).
To **promote export activities** the Saxon government offers significant support for companies aiming to become active on the international market, especially concerning consulting and their presence on international trade fairs.
To **tackle the unemployment problem** the labour unions, employer's associations and the Saxon State Government formed an Alliance for Labour (*Bündnis für Arbeit*) in 1997. Its aim is

to strengthen industrial networks and university-industry relations, and to support human capital initiatives in order to safeguard or even increase employment in the region.
Contrary to its generally unfavourable situation in terms of employment Saxony has one of the lowest state deficits per capita (€2,617, 2003) among all German states and thus ample room for the realisation of political support initiatives. Therefore, Saxony can still feature the nationally highest public budget investment quotas (~25%) in 2002 (SMWA, 2004:220).
In part, this is due to the fact that, as a former transition area which underwent significant structural transformation it Saxony has yet to catch up with the rest of the country in many respects, **Saxony is a major recipient of cross-subsidies from the German federal and European Union level**. Besides transfers from the **national solidarity pact** providing eastern German administrations with regular lump-sum transfers, Saxony has received a total of €47.5 billion joint-task funding as well as €31.5 billion from the ERP (European Recovery Programme) between 1990 and 2006. Saxony has thus received subsidies of €18,500 per inhabitant since unification, which is equal to the eastern German average (see www.bmwi.bund.de).

3.2.2 Policy instruments

3.2.2.1 National Level

Direct Subsidies

Business enterprises in Saxony, as in all other German states profit from the general sectoral support policy of the BMWi (*Branchenförderung*). Sachsen has benefited considerably from this in the energy sector. Additionally, being located in an eastern German state, enterprises in Saxony can generally apply for investment support (*Investitionsförderungsgesetz*) when they are extending their business operations. Technology orientation is not a precondition per se of receiving this support, the main target of which is job creation.
Similarly, the upgrading of the human capital base in the region is supported at the federal level by efforts by the *Bundesagentur für Arbeit* at a vocational training level, and in the form of general guidelines for university policy at a tertiary education level (in the context of the Bologna Process).

Support from Public Financial Institutions

Additionally, many RDTI relevant activities are supported at the national level via the public promotional banks. For example, KfW SME bank assists SMEs in raising capital via special programmes targeted on companies that are working on prospective technologies. The KfW Mittelstandsbank is also involved in round tables and advisory centres to discuss issues important to SMEs.
The KfW offers the following programmes mainly for SMEs and innovating enterprises.

- Micro Loan Programme (*Mikrodarlehen*): Small loans for up to €25,000 to help people become self-employed
- Start-up Funds (*Startgeld*): Loans for business founders, small entrepreneurs and self-employed professionals whose project does not cost more than €50,000
- Entrepreneur Capital (*Unternehmerkapital*): An innovative family of products for business start-ups, young and also established enterprises.
- Entrepreneur Loan (*Unternehmerkredit*)/International Entrepreneur Loan (*Unternehmerkredit Ausland*): Loans for investments and working capital (in another country).
- ERP Regional Promotion Programme (*ERP-Regionalförderprogramm*): ERP funds at favourable terms and conditions for investments in structurally weak areas.

Finally, the BMWi's federal initiative to streamline administrative procedures for SMEs and thus to free resources so they can, among other things, be mobilised for innovative activity (*Mittelstandsentlastungsgesetz*) is also relevant here.

Budgetary Perspective

In addition to these concrete measures, it is important to point out that many of the activities of the Saxon state government could not be undertaken without the significant inflow of external budgetary resources it receives.

- Firstly, this refers to the complex German system of budgetary cross-subsidies among the federal states that benefits Saxony and enables it to implement more substantial regional support measures than its general economic situation would otherwise allow (in 2003 Saxony received more than €4 billion from various sources).
- Secondly, Saxony has received a total of €7.5 billion for investment support from the early 1990s to 2003 (SMWA 2004:149), in the context of the **joint task 'improvement of the regional economic structure'**. In total the federal government granted €2.9 billion from 2001-2005 and €1.9 billion from 2006-2010 (budget plan figures; Deutscher Bundestag 2005, Deutscher Bundestag 2001). During the late 1990s, even more support was given, totalling around €1.5 billion annually.
- Finally, about €3.5 billion of **EU structural funding** was allocated to Saxony from 1994-1999 increasing to about €5 billion from 2000-2006. From 2007-20013 another €3.9 billion of EU funding is envisaged. From 1990 to 2004 a total of 21,443 EU-subsidised projects with a total investment volume of €41.8 billion (16% of regional total) were undertaken and €7.5 billion was invested in business-related infrastructure. Half of this investment was made by SMEs. Official sources quote the total public and private resources available for subsidies in the period from 2000-2006 as €11.2 billion.

3.2.2.2 Regional Level

Despite the considerable external support outlined above, the Saxon State Government does not solely rely on the inflow of external funding but uses its own fiscal power to complement this with significant spending at the regional level. Regional budget planning for 2007 envisages expenditures of €228 million for conventional business development that are not directly attributable to either joint-task or EU funding.
The main thematic policy priorities complementary to RTDI instruments and innovation capacity in the region include:

- A multitude of start-up support programmes and measures both on the federal and regional levels have been set up to help develop an **innovation and entrepreneurially friendly atmosphere.** These do not require projects to have a specific technology orientation. While these programmes do not affect technology oriented founders directly, they help to generate an atmosphere where start-ups are generally welcomed.

- **Development of human capital** is largely influenced by the development of regional higher education policy. Saxony has recently enacted new legislation to maintain the effectiveness of its university system despite continuously declining funds. However, a recent seminal project such as the Bologna process has resulted in an unusually high level of involvement of federal actors, even if final implementation continues to rest with the regional governments. With respect to ISCED 3-4 qualification, qualification programmes by the *Bundesagentur für Arbeit* and the local Chambers of Commerce play an important supporting role for the general absorptive capacity of the region.

- It is worth noting that, in contrast to the federal level, the Saxon government continues to support **networking initiatives and co-operation** in sectors which are not typically highly innovative. This is likely to have an impact on the general culture of networking, which in turn is highly relevant for cluster promotion.

- Finally, there are a lot of federal as well as regional **support measures for SME** even if they are not innovative. Most of this support is given in the form of KfW credits and guarantees or equity from the *Sächsische Beteiligungsgesellschaft*. Plain subsidies are usually only given to SME that decide to invest in particularly lagging regions or to those that have temporary difficulties. Additionally, Saxony's location in the former East Germany still enables enterprises to apply for **general investment support** (*Investi-*

tionszulagen) and enterprises from certain industrial sectors have general access to BMWi subsidies irrespective of their location.

Exhibit 2: Effects of policies complementary to RTD instruments on R&D capacity of the region

Policy Areas	Policies complementary to RTD instruments affecting policy area*	Effects on R&D capacity of the region
Improve R&D governance	Initiative to streamline administration (*Mittelstandsentlastungsgesetz*)	a general improvement of framework conditions for SME should facilitate their innovative efforts
Creation of an innovation friendly environment	***National level:*** Several start-up support programmes such as FUTOUR or start-up consulting measures financed by BMWi (€32.5 annually) Several KfW start-up programmes ***Regional level:*** start-up- and growth financing (GuW) Saxony (acquisition of equity) (€6.4 million[14]) ESF-microcredit for start-up entrepreneurs Business-plan competition future SAX (€700.000[15])	Availability of start-up measures covers and reduces risk for potential entrepreneurs. Innovative activities may later result from initially non-innovating start-up projects that would not have been started without such support. Likewise start-up support improves the general entrepreneurial climate that is needed by technology oriented start-up entrepreneurs who bear technological risk anyway and would thus likely be deterred in a start-up averse environment.
Development of human capital	***National level:*** National policy co-ordination of crucial issues such as the Bologna Process Support for qualification measures through the *Bundesagentur für Arbeit* and the *KfW* ***Regional level:*** Reform of the Saxon higher education legislation to improve performance despite financial restrictions (05/05) Support for vocational training by the local chambers of commerce	The human capital base is one of Saxony's strongest assets. However, the industrial sector still finds it difficult to retain sufficient R&D personnel for its own future expansion. The maintenance of an active source of human capital is therefore key to the region's future development, particularly with a view to the fact that it currently still suffers from a certain brain drain.
Networking, co-location and clustering measures	***National level:*** *All current federal support measures expect networks to be innovative* ***Regional level:*** Co-operation support from regional budget funding (sub-programme 5 of	Improves general culture of co-operation that cannot be initiated and maintained by R&D oriented co-operation support alone. However, such a culture is vital for R&D oriented co-operation to emerge and succeed.

[14] budgetary plan for SMWA 2007: sections 662 01, 662 02, 662 73
[15] budgetary plan for SMWA 2007: section 536 02

	SME support guidelines) Network initiatives of the State of Saxony (€4.6 million[16]) Aspect of some SME programmes	
Knowledge and technology transfer to enterprises	*none*	*none*
Research collaboration of public research organisations with private sector	*none*	*none*
Support of public research	*none*	*none*
Financial R&D measures for the private sector	***National level:*** Comprehensive SME credit, equity and guarantee schemes by *KfW (DtA)* General support for investment in eastern Germany (*Investitionszulagengesetz*) General subsidies for certain selected industrial sectors (*Branchenförderung*) ***Regional level:*** Equity and guarantee schemes of the MBG and SBG Support for local SME, particularly in lagging regions, for those trying to internationalise and/or facing temporary challenges (€16.9 million[17]) Investment support for single enterprises (€71.4 million[18])	General and broad availability of support measures improves financial situation of firms; SMEs that would otherwise be short of cash flow can mobilise capital for R&D. Certain industries profit from targeted subsidies that may also be redirected to innovative activities in the sector (e.g. the energy technology sector)
Other	National budgetary cross-subsidisation Joint task 'improvement of regional economic structure' (€256 million[19]) EU structural funding (ERDF €428 million[20])	Improves Saxony's general budgetary situation so that the state can pursue economic support policies it could not otherwise realise. Likewise, it provides the basis for general support measures to firms that may facilitate risk taking and innovation.

[16] budgetary plan for SMWA 2007: sections 537 01, 682 02
[17] budgetary plan for SMWA 2007: section 682 01, 686 10, 686 05, 893 73
[18] budgetary plan for SMWA 2007: section 892 01
[19] budgetary plan for SMWA 2007: section TG 70, TG 71
[20] budgetary plan for SMWA 2007: section 346 01 (Zuweisungen)

3.3 Conclusions

General Economic Development Trends

In terms of GDP per capita, Saxony occupies the middle ground among the German federal states with respect to its economic development. It is, however, a leader among the eastern German states that have had to deal with the challenges of economic transformation.

Saxony was traditionally a leading industrial region in both pre-war Germany and the GDR. This historic background provided the region with relevant education institutions and a solid human capital base. However, the GDR's planned economy was not structured according to market needs, so that in the course of systemic transformation most of the regional industrial base inevitably collapsed. Few assets could be put to new use directly and even about 15 years later Saxony is still recovering from this disruption.

Following unification the region's industrial base has been gradually restored often with western German or foreign investment. In parallel, a dynamic endogenous SME sector emerged (and was preserved) and remains a constitutive element of its economy today. It was therefore possible to raise productivity from 40% of the national average to 70% over the five year period from 1991 to 1996 (see Fig. 10). Investment per employee was and remains higher than in the western states today.

Today, consequently, most economic activity is either performed in large units set up in the mid 1990s or traditional SMEs. Many larger units are subsidiary production facilities that do not perform much R&D on-site. Not surprisingly, therefore, employment in the high-tech and medium-tech industrial sectors, as well as in knowledge intensive service sectors, remains below the national average. Recently, however, industrial R&D has gained importance with the increased presence of large technology-oriented multinational enterprises such as Infineon and AMD.

The clearest legacy of economic transformation today remains the (far) above average unemployment rate, which in some communities remains high even by eastern German standards. Another indicator pointing to the decline left by the collapse of the planned economy is the above average construction activity. The peak in "catch-up" building activity in the mid 1990s, however, is over and the overall dominance of the construction sector has decreased considerably since.

Despite the significant economic challenges that the region faces, its government commands plentiful budget resources due to federal cross-subsidies and the allocation of funding from EU regional policy and the national joint task called 'improvement of the regional economic structure'.

Trends in the Relationship between RTDI Investments and Economic Development

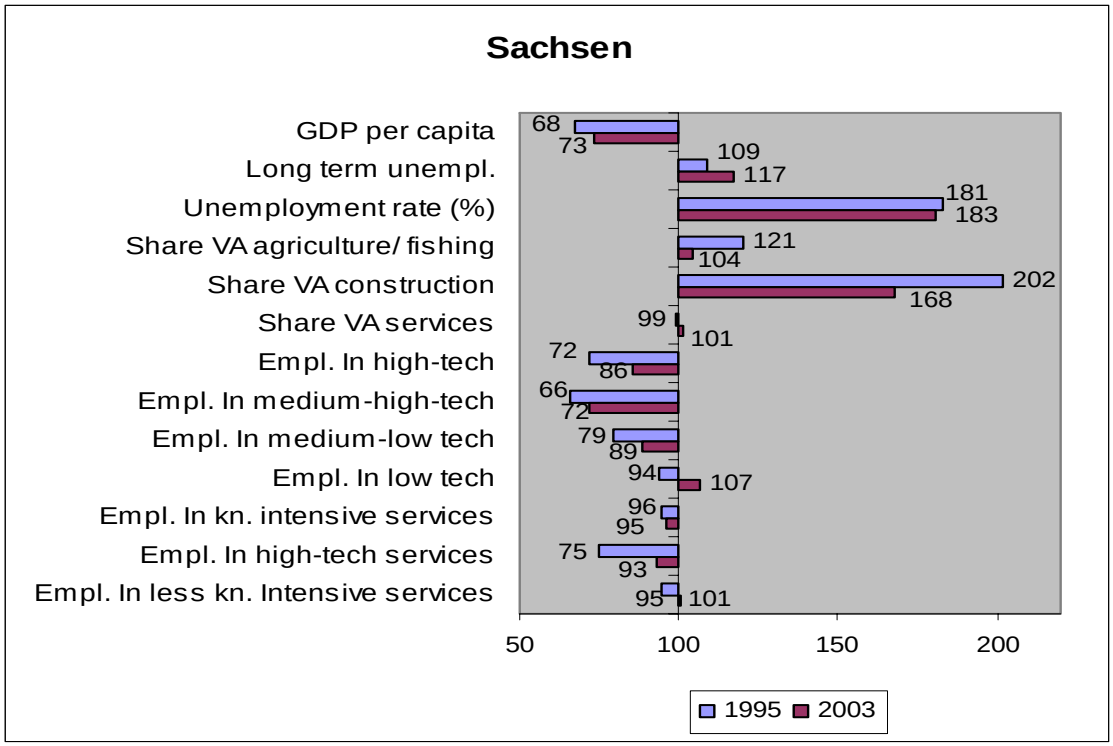
It is difficult to establish a direct connection between R&D investment and general economic indicators in a post-transition economy such as Saxony. The outstanding productivity and unemployment issues demonstrate that much of local economic development still hinges on other factors than the question of whether the region produces internationally competitive products or research results. For example, a significant upturn in industrial production has occurred since the late 1990s with the consequent impact on the whole range of general economic indicators (rises in GDP, productivity, etc.) yet this has not resulted in a structural change in industrial R&D investment. When discussing the impact of R&D investment it has to be taken into account that one important feature of the region's economy is the strong SME sector much of which is also engaged in medium- to low-tech production so that its development is not always directly susceptible to any public or PPP RTDI investment initiatives.

Two Stages of Development

One tentative conclusion that can be drawn, however, is that the expansion of Saxon exports (see Fig. 12) and their rising high technology intensity (see p. 29) indicate a structural change in the industrial sector and an increase in international competitiveness. Interestingly, this began at a time when the development trends in many of the general economic indicators such as productivity and GDP were becoming less dynamic (since 1996). This conclusion may be sup-

ported by the relative increases in the share of employment in high-tech industrial production and knowledge intensive production as shown in Figure 13 and Figure 14 (Annex 3).
The data seem to suggest that the mid 1990s were a watershed between a catch-up development, mostly driven by the general recovery and domestic demand, and a technological capability based development, based on a newly acquired international competitiveness. While other factors certainly play a role it seems likely that both general economic policy and public RTDI investments have helped to initiated and shape this trend as well as to sustain it until the present.

Graph 2: Comparison of Saxony's economic structure with the economic structure of Germany



Note: Long term unemployment, unemployment rate and VA construction 1999, 2003

4 Conclusions

4.1 Assessment of the regional innovation system

The regional research infrastructure in Saxony had to be largely rebuilt following German unification in 1990. In fact, much of the GDR's industrial base collapsed in the early 1990s and with it much of the regional innovation potential of the State of Saxony. Much effort that was put into sustaining industrial research capabilities over the period of de-industrialisation has not proven successful in all cases (external industrial research agencies, see above). However, the state government was in the unusual position of being able to command sufficient means to build up a new public research system to serve as a basis and a nucleus for future economic activity. Additionally, it had a strategic policy vision and focused on encouraging investments in certain key sectors. The public research and the business side of the regional innovation have thus evolved jointly in the past fifteen years so that Saxony is characterised by an above average fit between regional economic structure and public research capacities. Nevertheless, the regional business R&D system remains weakened and has not yet become an appropriate match for the strong public research base.

The weakness of the R&D potential in the business sector is due to the fact that Saxony continues to harbour a large share of declining industries (mining) as well as overly SME oriented industries that are not sufficiently complemented by larger industrial enterprises and/or public research units (mechanical engineering). On the other hand some industries such as the automotive sector are focused on highly productive production-oriented units yet remain branches of larger corporations that do not perform much R&D regionally.

However, many industries also show positive development trends with respect to industrial R&D, such as the IT/microelectronics sector. Saxony features a surprisingly large number of clusters in different stages that encompass all or most important actors such as SMEs, large units and public research bodies and that are appropriately supported by public policy. The most prominent and furthest developed of them is the IT cluster ('Silicon Saxony'), followed by the emerging biotechnology and the still very nascent nanotechnology cluster.

It is clear that the Saxon innovation system is no match for those of leading German regions such as Baden-Württemberg and it is likely that it will not be for a considerable time to come. Additionally, much of its innovative potential is based on public research institutes instead of the private sector. This can be a drawback when international investors looking for investment opportunities in Germany choose to locate in a more established environment. Nevertheless, the Saxon innovation system is arguably the most developed among the New German *Länder* and is beginning to outperform those of weaker western German states such as Rhineland-Palatinate, Saarland and Schleswig-Holstein in terms of GERD/GDP as well as in terms of absolute GERD.

The availability of technology transfer agencies in Saxony is sufficient though not always clearly optimal. Technology parks and incubators serve as regional anchors and nuclei for business development. However, too much effort may in the past have been put into the development of too many community level technology parks and incubators. Not all of them can sensibly be filled with adequate high-tech start-up tenants so that some of them have adopted a general business development function they are neither designed for nor very useful for.

The general level of higher education in Saxony is sufficient to provide knowledge intensive industries and business service sectors with adequate human resources. With respect to complementary technical personnel the well developed German system of vocational training accommodates the needs of enterprises. However, the prevalence of life-long learning could be improved and the general unemployment problem in the region also affects qualified graduates who might be tempted to migrate.

The interaction between the important players in the Saxon innovation system is furthered by the cluster initiatives described, consistently supported and facilitated by the state government and therefore generally good. However, the task remains complex due to the SME-based nature of the Saxon business sector and the fragmentation of 'technology fields' –supported as if they were coherent– so that the current situation still leaves ample room for improvement.

The governance capacity of the regional government is well developed by German standards. To a large degree this is due to the fact that the German federal states are responsible for the drafting of the operational programmes for ERDF and ESF. Since Saxony receives substantial support from these sources and its budgetary powers are topped up by lump-sum federal transfers (*Solidarpakt*), the state of Saxony has a capacity to implement policies that other states, even within Germany, do not have.

Exhibit 3: Strengths and weaknesses of the regional innovation system

	Strengths	***Weaknesses***
Knowledge creation capacity	• University education focused on technical subjects to an appropriate degree • Above average basis of public R&D infrastructure	• Weakness in absolute terms which at times prompts industrial firms to locate elsewhere • Below average basis of industrial R&D capabilities
Knowledge diffusion capacity	• Availability of a network of technology transfer centres	• Efficiency and adequacy of the total range of technology transfer agencies is disputable • Too many technology parks and incubators to remain efficient
Knowledge absorption capacity	• Generally high level of education • Comprehensive vocational training	• Unemployment issues also concern highly qualified jobs • Lack of life-long learning
Interactions of main actors	• Good interaction within the cluster frameworks	• Complexity of interaction due to the large number of enterprises • Large units tend to perform much R&D in-house
RTD governance capacity	• Less budgetary restraints than in other federal states • Qualified business-oriented administration • As a new *Land* Saxony can still access federal support targeted to less successful states with less innovative potential	
Knowledge vs. economic specialisation	• Generally good – targeted creation and agglomeration of research institutes with a view to future cluster development	• Some industries (e.g. automotive) have potential to locate more R&D in Saxony but do not
Economic Structure	• Adequate legislative framework	• Lack of large units • Unemployment issues • Lack of availability of capital

4.2 Assessment of policies

Early on, the Saxon government decided to focus development on key technology fields that promised future growth potential and had not yet been too strongly established in western Germany. In combination with a largely specific-purpose allocation of ERDF funding and federal cross-subsidies this policy has turned out to be a fully fledged success. Additionally, it is important to note that the regional R&D support policies have always remained open to applicants from all industries so that the responsible ministry had continuous feedback on whether

its selection of technologies still fits in with economic realities. Together with the increase in programme evaluation in the late 1990s, this may be one of the key reasons for success.
Likewise, Saxony was relatively successful in establishing interim measures to keep researchers in the region before the industrial R&D system recovered in the mid 1990s, and to ensure its R&D support policies remained accessible to SMEs even when attracting large firms became the major focus of business development policy in the late 1990s. Finally, the way responsibilities are shared between the regional and the federal level seems to be well devised. The task of general credit support schemes has sensibly been left to the federal institutions (KfW and formerly DtA).
In summary, experts find (Schmalholz, 2005) that the success of Saxon economic and R&D support policy comes down to three main reasons: That support is distributed evenly across –a selected number of– fields, that the number of support programmes has been kept low and easy to understand, and that there are few overlapping measures.
A major drawback, however, that is not unique to the region of Saxony is that programmes that have been found to have become ineffective are being continued too long before they are finally phased out. Some reports have suggested that in Saxony this may have been the case with unmonitored support for R&D personnel (DIW, 2001:239; Müller, 2001:24), support for technology parks and incubators (Müller, 2001:18f) and support for the external industrial research associations (Müller, 2001:18, 24). There is, however, no unanimous view on this topic.
Likewise, it remains an open question whether the number of innovating SMEs can still be substantially bolstered by political support measures or if spending much more money on this effort would be inefficient. More in-depth research on this issue is needed.

Exhibit 4: Public Policy vs. Strengths and Weaknesses of RIS

[S&Ws from Exhibit 3]	**Effective approaches** *[only measures which appear to have a significant contribution to facing the S&Ws are presented]*	**Failures** *[only measures which appear to have a significant negative effect or failed to address the S&Ws effectively]*
Strengths		
Knowledge creation capacity	Extension of capacities of local braches of the large German public research organisations such as MPG, FhG, WGL Successful reform of higher education institutions	External industrial research associations model (served its purpose to temporarily bind researchers but did not develop much future potential)
RTD governance capacity	Well targeted and well considered allocation of ERDF-funding and other available subsidies Even distribution of funding across a selected number of technology fields Low number of support programmes; easy to understand and non-overlapping measures	Measures to substantially tackle unemployment and/or to improve life-long learning
Knowledge absorption capacity	Successful reform of higher education institutions	
Economic Structure	1992 guidelines for technology policy and resulting cluster policies Conscious timing of cluster support activities	
Weaknesses		

Knowledge creation capacity	National credit support schemes alleviate the hurdles to innovation in the business sector caused by the deficient financial system	Support schemes have failed to substantially boost the number of innovating SMEs (limit reached?)
RTD governance capacity	Effective sharing of responsibilities between the national and the regional/EU implementation level	Unmonitored personnel support schemes (in the 1990s) have invited firms to seek windfall gains
Knowledge diffusion capacity/ Interactions of main actors	Focus on co-operative R&D support programmes addresses the needs of local SME	

4.3 Policy challenges

In short, three major challenges can be identified for the Saxon innovation system.
Firstly, as an eastern German region, Saxony's process of catching-up is likely to continue for one or two decades to come before the state will have re-established itself as a leading region in Germany, as the government currently envisages. The structural weakness of business sector R&D is therefore a major challenge to its development that cannot be tackled in the short term but requires consistent long-term measures. With respect to the Lisbon objective, significant improvements can therefore only be expected from long-term measures since the capacity of public actors to raise expenditures in an appropriate manner has already been strained.
Secondly, there are mid term issues such as those concerning the development of the higher education system. While the Saxon higher education system is structurally sufficient, decision-makers have to keep track of the current increase in competition among German universities so as not to fall too far behind the leading national institutions. Likewise, lump-sum budgetary transfers from western Germany will start to decrease from 2008 onwards so that the SMWA will have to reconsider, if not its policy design, at least the set up of the regional funding system for R&D support. There are also specific challenges that differ from sector to sector such as the lack of R&D in the automotive sector, the lack of larger enterprises in the mechanical engineering sector etc. that could be tackled within a timeframe of five to ten years.
Thirdly, there are short term issues and challenges. In general Saxon support policy can be characterised as modern so that there is no general need to introduce certain specific measures. In the short run it will be crucial to turn individual programmes, such as the nanotechnology cluster initiative, into a success. This is on the one hand necessary to justify the investment and on the other to reinforce political legitimacy for the more basic key technology support concept that has already proven appropriate twice in the past, but may come in for criticism as soon as an expensive initiative fails to deliver on its promise.
With respect to its general level of international competitiveness, the Saxon economy appears well positioned to handle the challenges of the knowledge economy. Increasing exports show that the efforts made in the 1990s and the early 2000s are beginning to bear fruit. Nevertheless, Saxony has to keep up its efforts to reap the benefits of its successes on a broader basis than is currently possible. In the field of high-tech, the IT cluster is so far the only Saxon cluster to have become truly self-sustaining. For the moment this leaves Saxony somewhat vulnerable to economic cycles in the IT sector. Likewise, Saxon competitiveness is still very much based on R&D performed by large companies and thus dependent on individual location decisions. Consequently, the basis of international competitiveness needs to be broadened in the future.

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Annex 1: Definition of policy mix typology

- **Improve R&D governance capacity**: Technical assistance type funding used by public authorities, regional agencies and public-private partnerships in developing and improving policies and strategies in support of R&D investments. This could include changes in the organisation of decision making, national and regional foresight, measures for improvement of evaluation etc.
- **Creation of an innovation friendly environment**: This category covers a wide range of actions which seek to improve the overall environment in which enterprises, universities and research organisations innovate. In this category the following measures are included:
    - Regulation and initiatives addressing the intellectual property rights either by improving legislation in cases of commercialisation of public or collaborative research or by covering protection costs
    - Direct or indirect support of spin-offs and New Technology Based Firms (NTBFs). Direct support includes public financial schemes such as pre-seed and first stage capital, while indirect measures include funding of incubators, training related to entrepreneurship, etc.
- **Development of human capital:** This category includes measures aiming at the upgrading of human resources in R&D and innovation related activities, such as supporting science and technology graduates to follow research and innovation-oriented careers; training of researchers in enterprises or research centres; intra- and international mobility of scientists; curriculum development in higher education aimed at developing science and technology; orientated under- and post-graduate courses etc.
- **Networking, co-location and clustering measures**: Policies under this category focus on promoting R&D cooperation, networking and interaction. Measures promoting co-location of industrial and scientific organisations (e.g. innovation poles), funding for clusters infrastructure and activities with technological and R&D orientation are some of possible interventions under this category.
- **Knowledge and technology transfer to industry**: This category includes policies supporting directly or indirectly knowledge and technology transfer from universities and public research organisations and commercialisation of public research results. Direct support includes aid schemes for utilising technology-related services or for implementing technology transfer projects from public or private sector to the private sector. Indirect policies include development of infrastructures facilitating technology transfer such as technology parks, innovation centres, university liaison and transfer offices, etc.
- **Research collaboration of public research organisations with private sector:** Measures supporting collaborative research projects and development of common (for use by private and public sector) research infrastructures are included.
- **Support of public research:** Measures under this category include:
    - Public investments in research infrastructure and direct funding of public R&D e.g. setting up new infrastructures, or supporting centres of excellence

- Grants for R&D projects implemented in Universities and other Public Research Organisations
- Regulatory changes and incentives for universities and other public research organisations which encourage the commercialisation of research results and collaboration with industry

- **Financial R&D measures for the private sector**: Two main categories of measures are included:
  - **Direct and indirect financial R&D measures for the private sector:** Direct measures **i**nclude direct public funding of R&D in the private sector e.g. grants, conditional loans etc. Indirect measures include tax incentives for firms to undertake R&D activities.
  - **Catalytic Financial R&D Measures for the private sector:** Includes instruments facilitating the access of R&D performers to external private sector sources of finance. Typical measures of this type are measures encouraging the use of *risk capital* (e.g. venture capital funds) for both R&D and innovation related activities and the *loan and equity guarantee measures.*

Annex 2: Description of key indicators used in Summary Graphs 1 and 2

Period of coverage: Two years are used i.e., 1995 and 2004 or the closest possible years
Index: Country=100
Source: Eurostat, 2006

Summary Graph 1: Key indicators of region's knowledge base development in comparison to country

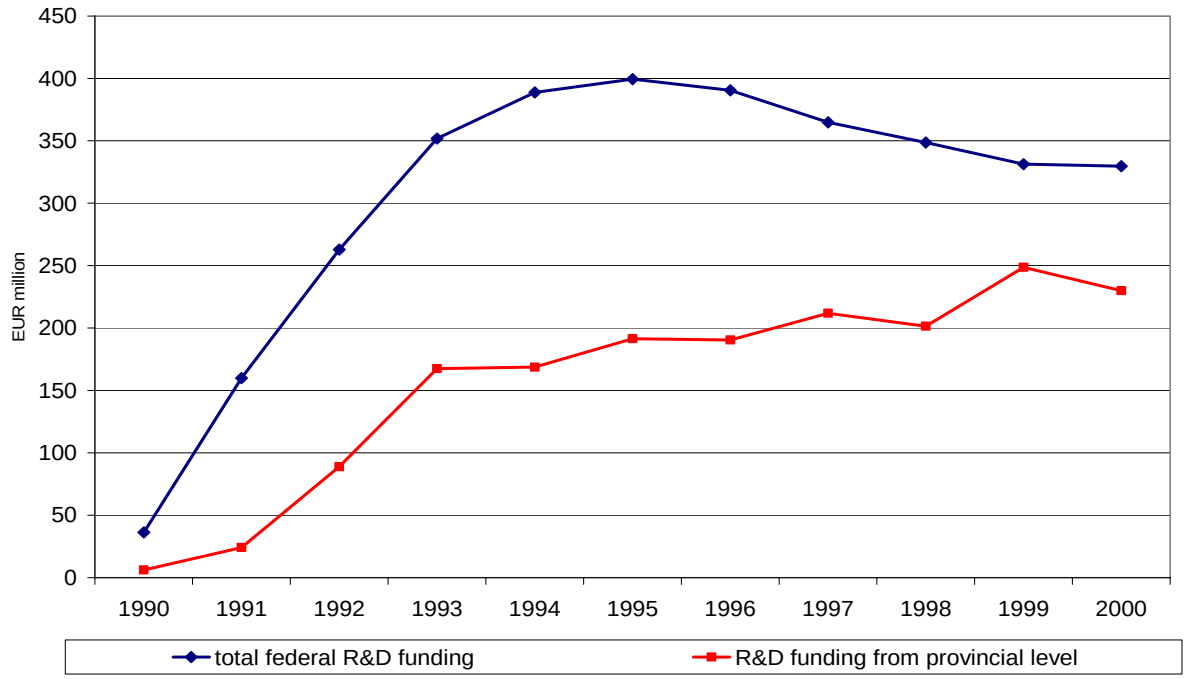
1. Total intramural R&D expenditure as a percentage of GDP
   - GERD
   - BERD
   - GOVERD
   - HERD
   - PNPERD .
2. R&D personnel as a percentage of total employment
   - All sectors
   - Business
   - Government
   - Higher education
   - Private non-profit
3. Human Resources in S&T as a percentage of labour force
4. Patent applications at EPO per million inhabitants
5. Students in tertiary education (ISCED 5+6) per thousand inhabitants.
6. Life Long Learning: Participation of adults aged 25-64 in education and training as a percentage of population

Summary Graph 2: Key indicators on Region's economic structure and development

1. GDP per capita at current market prices.
2. Long-term unemployment rate (on total unemployment).
3. Unemployment rate (%).
4. Value-added at basic prices (EUR million): Share (%) of sectors to total.
   - Agriculture/ fishing
   - Mining and quarrying
   - Manufacturing
   - Electricity, gas and water supply
   - Construction
   - Services (excl. extra-territorial organizations and bodies)
5. Annual data on employment in technology and knowledge-intensive sectors at the regional level : Percentage of total employment
   - High technology manufacturing: NACE Rev. 1.1 codes 30, 32 and 33
   - Medium high technology manufacturing: NACE Rev. 1.1 codes 24, 29, 31, 34 and 35
   - Medium low technology: NACE Rev. 1.1 codes 23 and 25 to 28
   - Low-technology: NACE Rev. 1.1 codes 15 to 22 and 36 to 37
   - Total knowledge-intensive services: NACE Rev. 1.1 codes 61, 62, 64 to 67, 70 to 74, 80, 85 and 92
   - Knowledge-intensive high-technology services: NACE Rev. 1.1 codes 64, 72, 73
   - Total less-knowledge-intensive services: NACE Rev. 1.1 codes 50, 51, 52, 55, 60, 63, 75, 90, 91, 93, 95 and 99

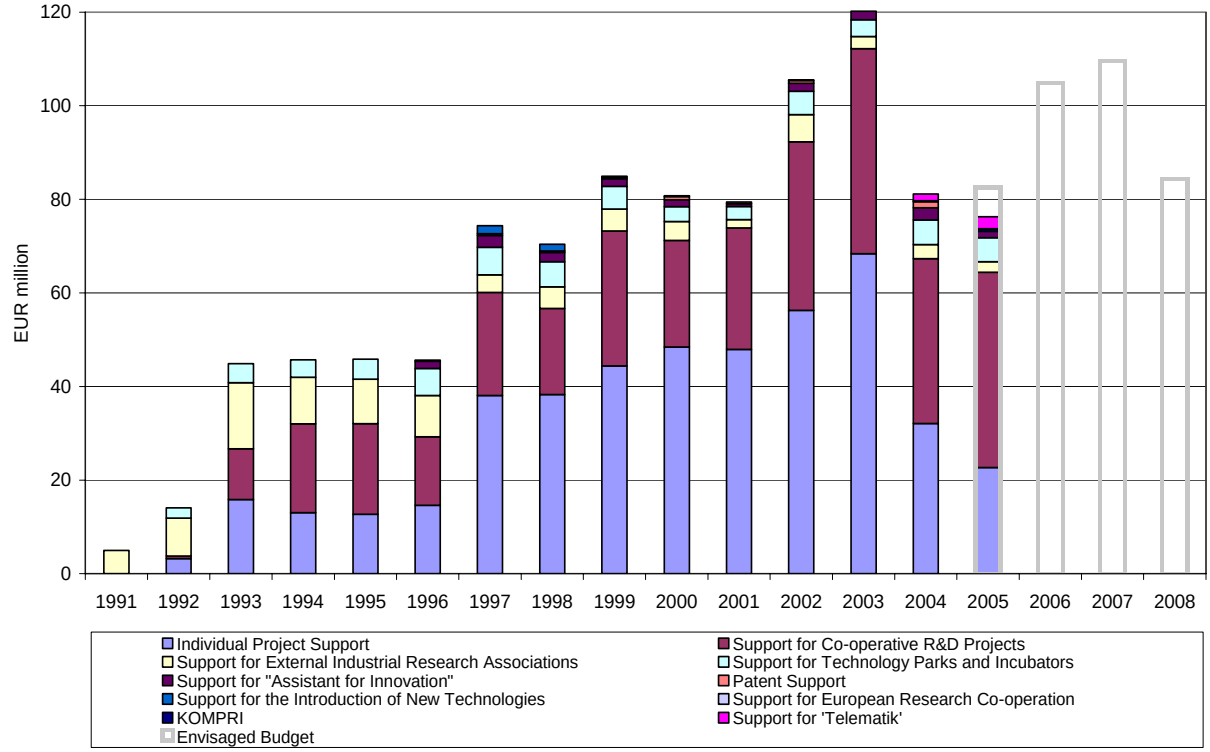
Annex 3: Tables and Figures

Figure 2: Technology Support Subsidies Allocated to Eastern Germany



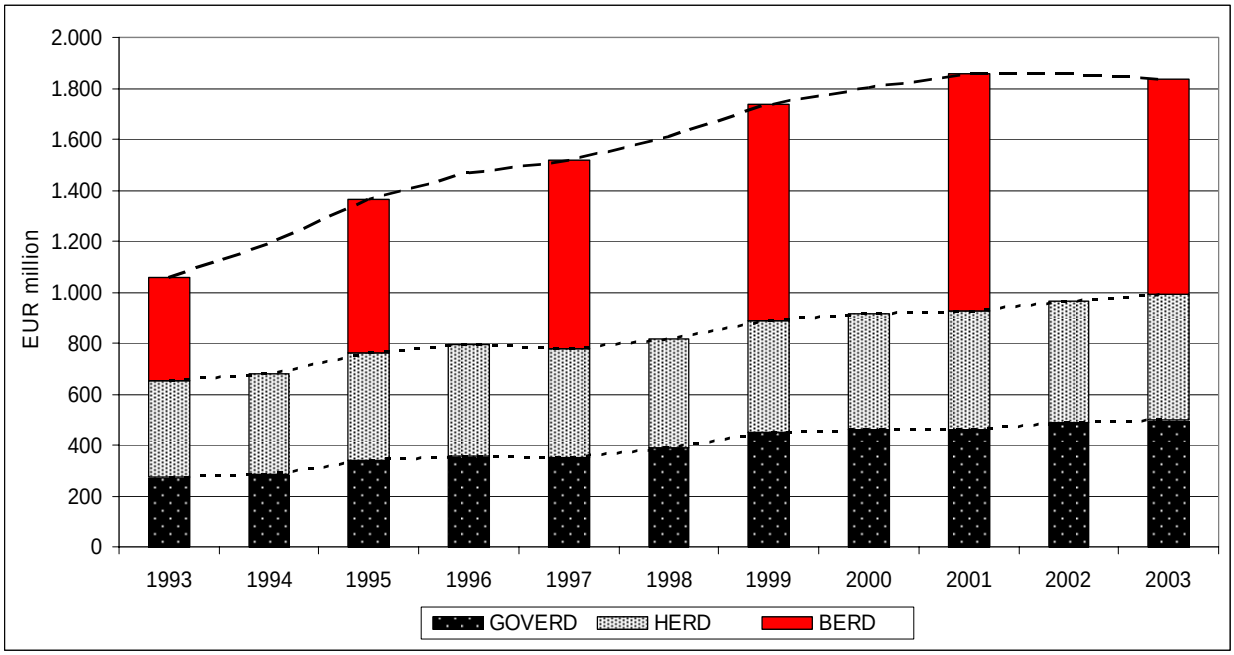
Source: DIW, 2001; own diagram

Figure 3: Development of Regional RTDI Support in Saxony



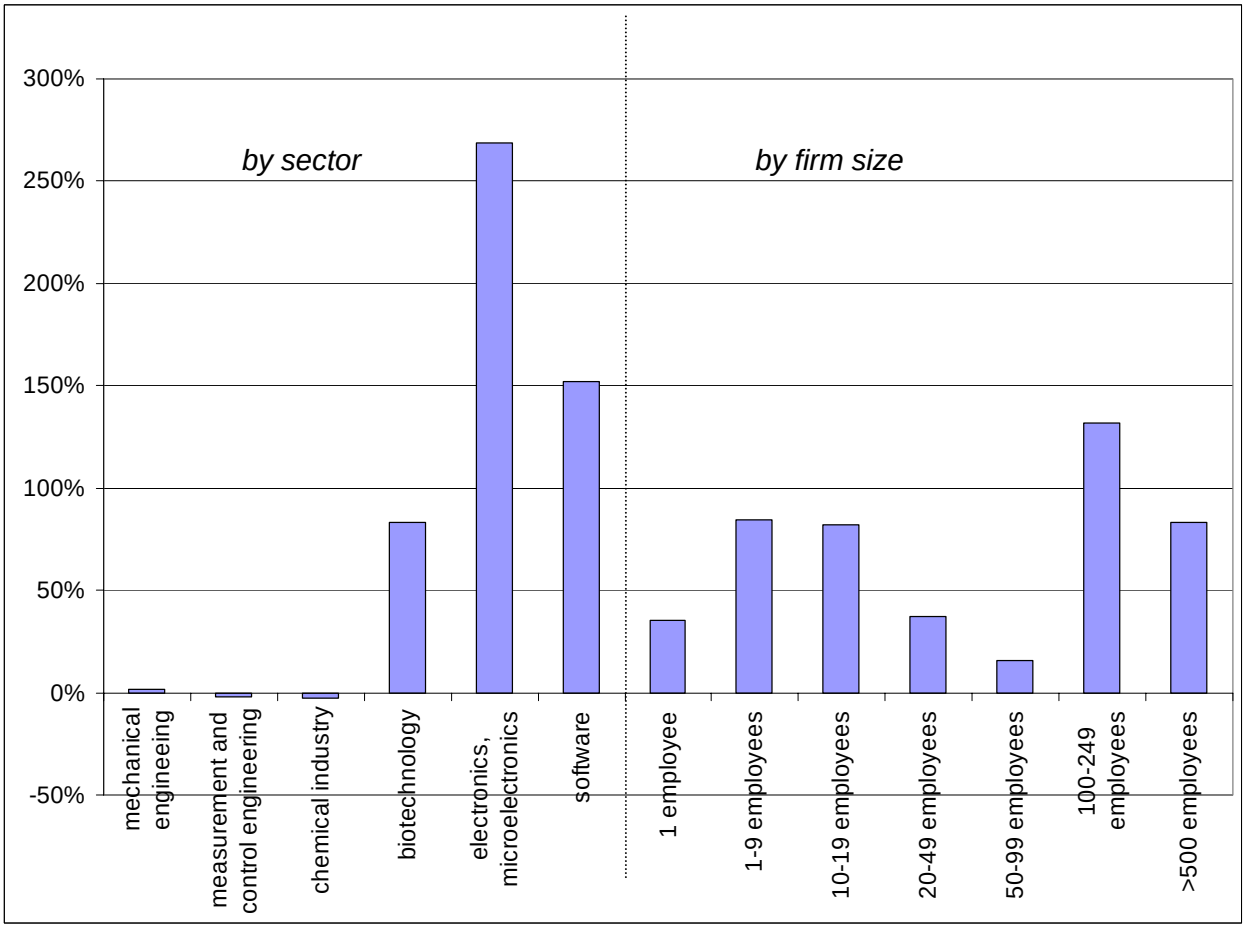
Source: Riedel 2002; SAB 2001-2006, own diagram

Figure 4: Development of GOVERD/HERD and BERD in Saxony 1991-2003



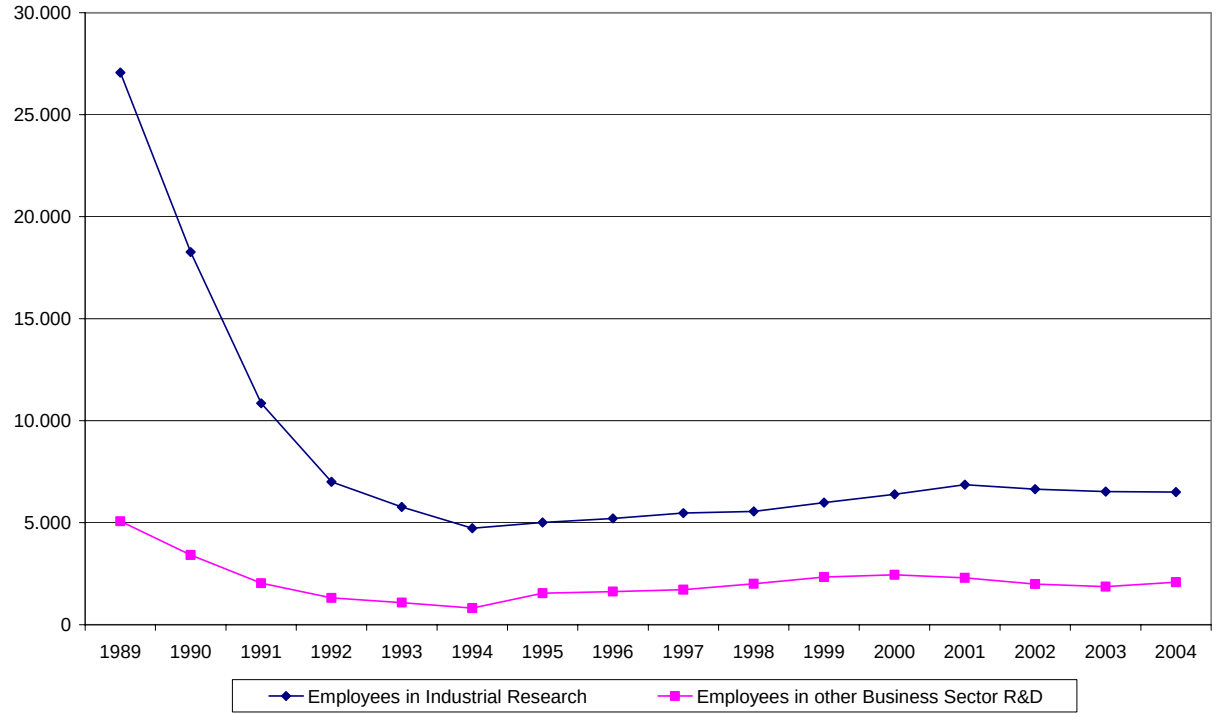
Source: Eurostat [2007], own diagram

Figure 5: Development of Business Enterprise Expenditure for R&D in Saxony 1996-2000



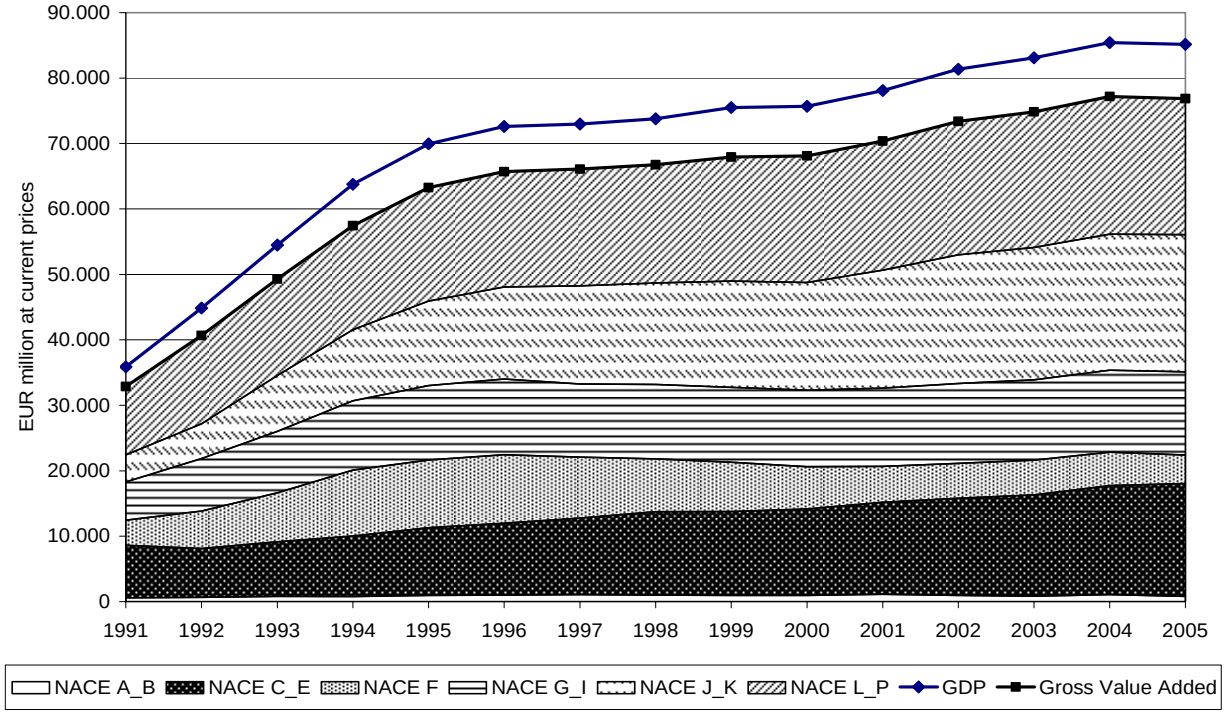
Source: SMWA (2002), own diagram

Figure 6: Collapse of R&D Employment in the Business Enterprise Sector Following Re-unification



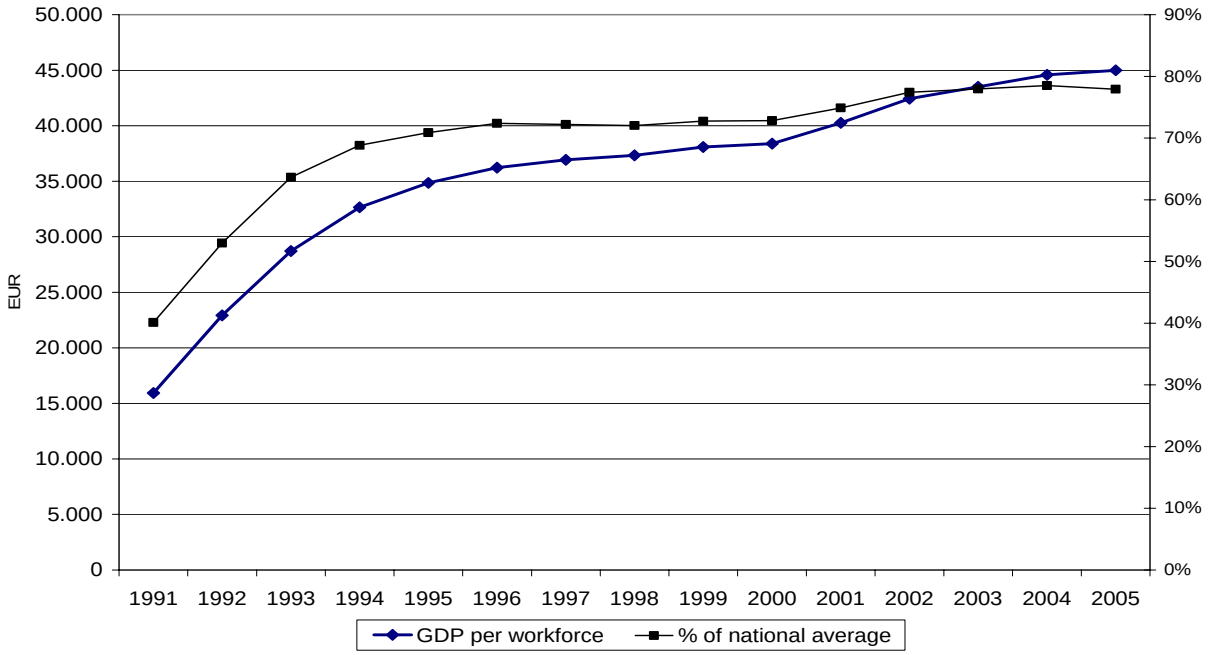
Source: Euronorm, 2005, own diagram

Figure 7: Development of GDP and Gross Value Added by NACE sections 1991-2005



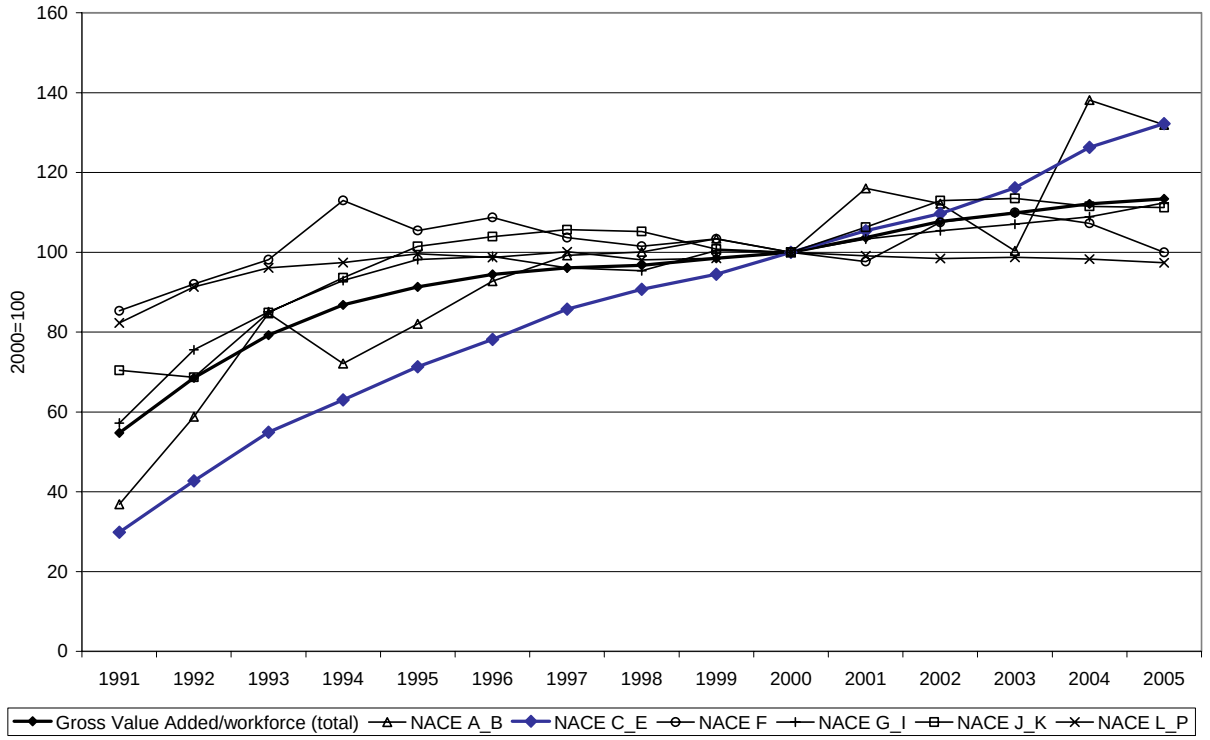
Source: Regional Statistical Office, own diagram

Figure 8: Development of productivity in Saxony 1991-2005



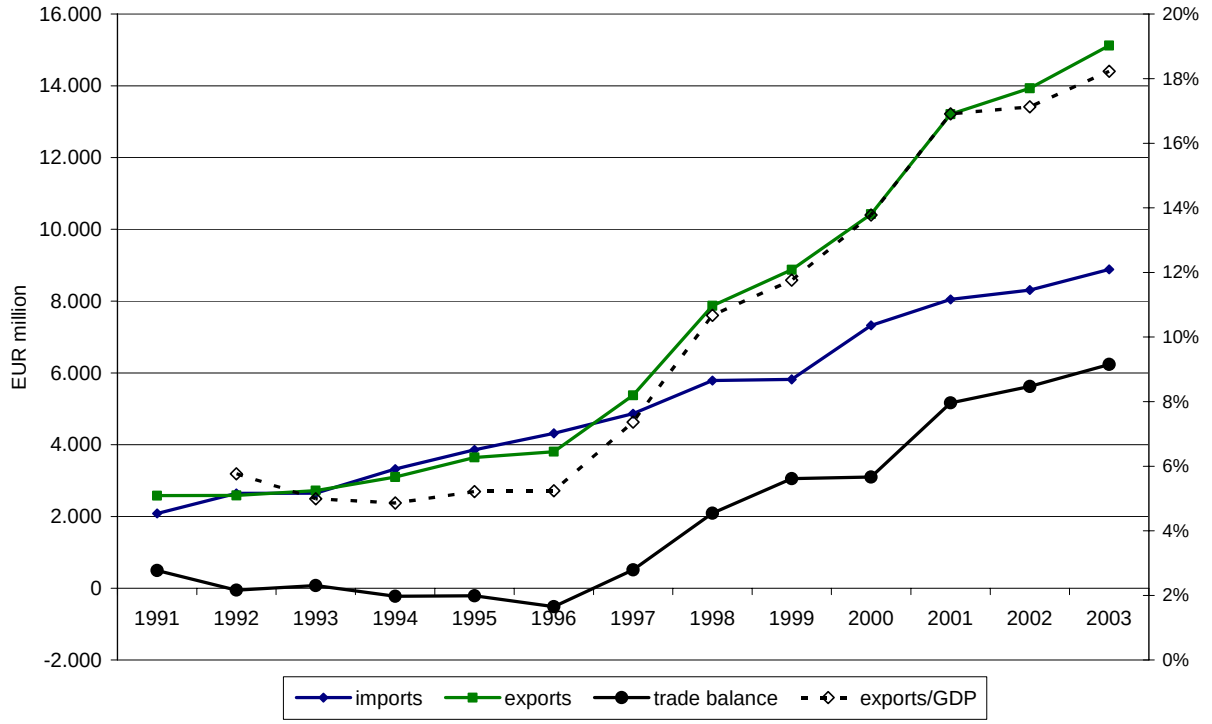
Source: Regional Statistical Office, own diagram

Figure 9: Development of productivity index by NACE sections in Saxony 1991-2005



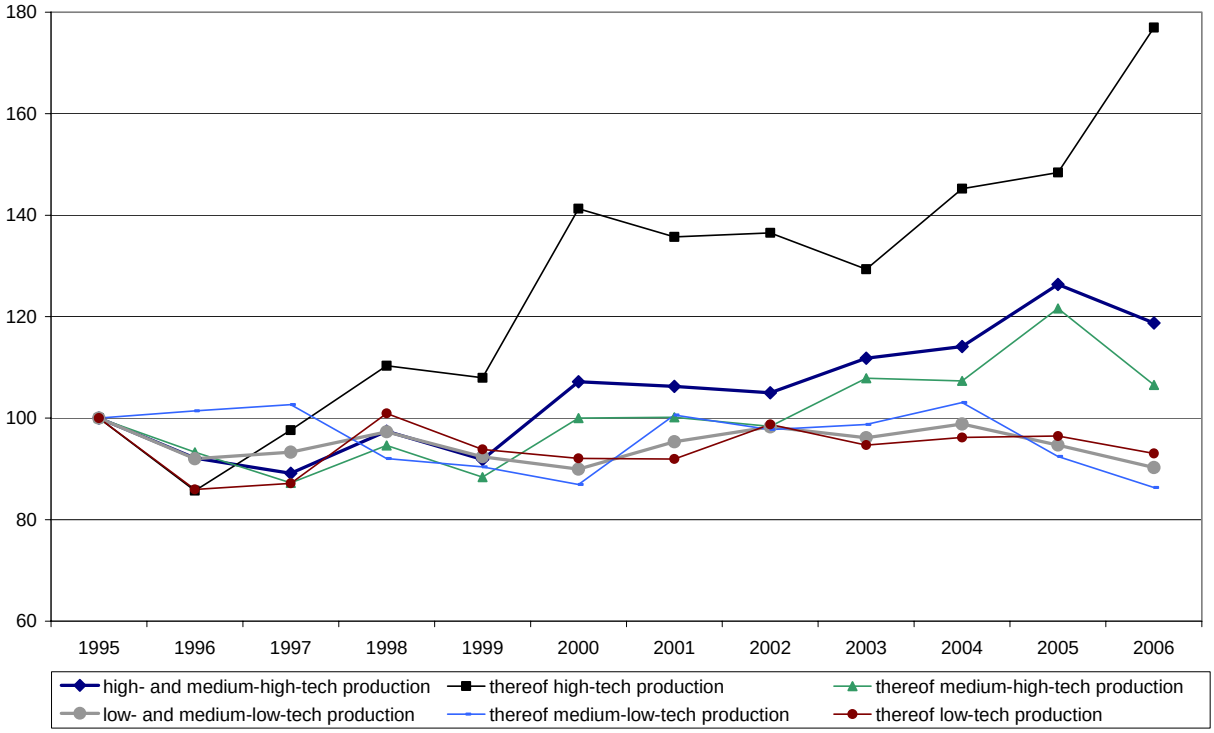
Source: Regional Statistical Office, own diagram

Figure 10: The Saxon Trade Balance 1991-2005



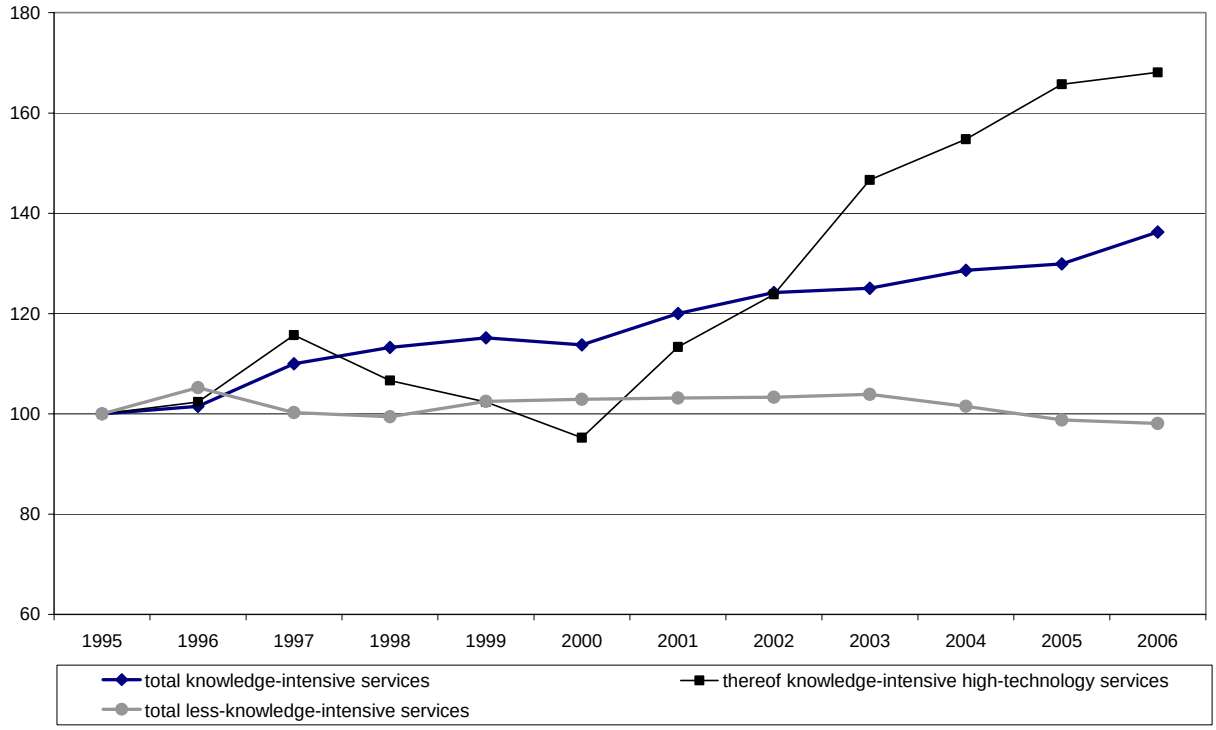
Source: www.sachsen.de; own diagram

Figure 11: Development of Industrial Sector Employment (as % of total employment) by Technology Orientation of Activity (1995=100)



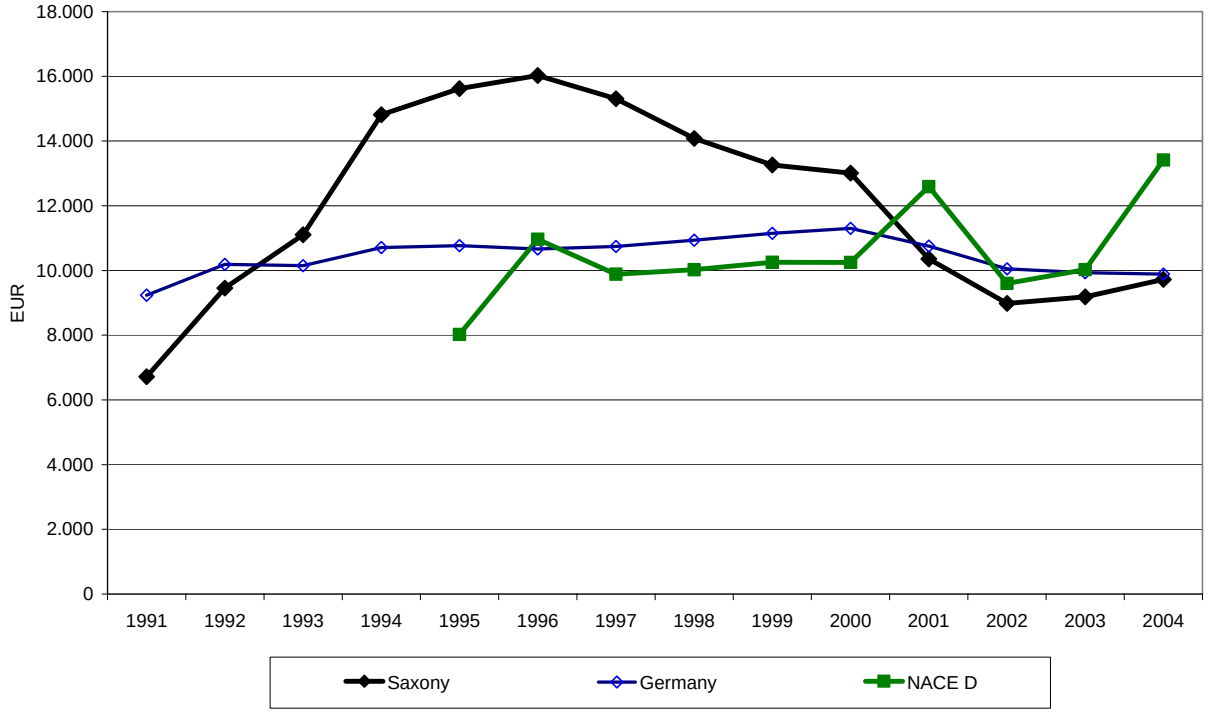
Source: Eurostat [2007], own diagram

Figure 12: Development of Employment in the Service Sector (as % of total employment) by Technology Orientation of Activity (1995=100)



Source: Eurostat [2007], own diagram

Figure 13: Gross Investment in Fixed Capital per Employee in Saxony 1991-2004



Source: National Statistics, own diagram

Table 1: Expenditure on Research and Development in Saxony 1993-2003 (EUR million)

	1993	1995	1997	1999	2001	2003
BERD	406,4	605,2	741,4	845,0	935,0	847,4
GOVERD	276,3	338,9	352,2	448,0	461,0	497,7
HERD	374,6	420,6	426,5	442,0	463,0	491,8
total	**1057,3**	**1364,7**	**1520,1**	**1735,0**	**1859,0**	**1836,9**
as % of total						
BERD	38,4%	44,3%	48,8%	48,7%	50,3%	46,1%
GOVERD	26,1%	24,8%	23,2%	25,8%	24,8%	27,1%
HERD	35,4%	30,8%	28,1%	25,5%	24,9%	26,8%

Source: Eurostat [2007]

Table 2: Employment in R&D in Saxony 1995-2003 (Full Time Equivalent)

	1995	1997	1999	2001	2003
BERD	9.891	11.438	11.496	11.057	9.211
GOVERD	3.863	4.083	4.427	4.420	5.005
HERD	5.938	6.011	5.795	5.809	5.816
total	**19.692**	**21.532**	**21.718**	**21.286**	**20.032**
as % of total					
BERD	50,2%	53,1%	52,9%	51,9%	46,0%
GOVERD	19,6%	19,0%	20,4%	20,8%	25,0%
HERD	30,2%	27,9%	26,7%	27,3%	29,0%

Source: Eurostat [2007]

Table 3: Expenditure on Research & Development in Saxony by the Federal and the Regional State Government

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
federal	410	410	360	352	387	391	412	434	409	400	406
in % of national total	5,4	5,3	4,9	4,8	5,4	5,3	5,3	5,5	5,2	5,2	5,2
state	454	534	535	n.a.	534	559	626	625	634	619	n.a.
in % of national total	6,2	7,1	7,2	n.a.	7,0	7,2	8,1	7,7	7,9	7,8	n.a.

Source: BMBF 2000, 2004, 2006

Table 4: Large Companies with a high potential for R&D activities in Saxony*

Automotive	
Volkswagen Sachsen GmbH, Motorenfertigung	Chemnitz
Siemens VDO Automotive AG	Chemnitz
Volkswagen Mechatronic GmbH & Co. KG	Chemnitz
IAV GmbH	Chemnitz
ThyssenKrupp Drauz Ingenieurbetrieb GmbH	Chemnitz, Zwickau
Autoliv Sicherheitstechnik GmbH, Werk Ost	Döbeln
Automobilmanufaktur Dresden GmbH (Gläserne Manufaktur)	Dresden
Karosseriewerke Dresden GmbH	Dresden
ZMD AG	Dresden
TAKATA-PETRI (Sachsen) GmbH	Dresden, Erzgebirge
Federnwerke Marienberg GmbH	Erzgebirge
Kuka Werkzeugbau Schwarzenberg GmbH	Erzgebirge
Blechformwerke Bernsbach AG	Erzgebirge
BMW AG, Werk Leipzig	Leipzig
Porsche Leipzig GmbH	Leipzig
Car Trim Fahrzeugausstattungen Produktionsgesellschaft mbH	Plauen
BuS Elektronik GmbH & Co. KG	Riesa
Volkswagen Sachsen GmbH, Fahrzeugfertigung	Zwickau
Brose Fahrzeugteile GmbH & Co. KG	Zwickau
Johnson Controls Objekt Zwickau GmbH & Co. KG	Zwickau
Tower Automotive Presswerk Zwickau GmbH & Co. KG	Zwickau
Biotech	
Chemieanlagenbau Chemnitz GmbH (CAC)	Chemnitz
Linde-KCA-Dresden GmbH	Dresden
SAXONIAMEDICAL GmbH	Dresden
ABX advanced biochemical compounds GmbH	Dresden
G.E.O.S. Freiberg Ingenieurgesellschaft mbH	Dresden
Cenix BioScience GmbH	Dresden
Endress+Hauser Conducta	Dresden
CyTecs GmbH	Görlitz
VITA34 AG	Leipzig
BUSSE GmbH	Leipzig
CORTEX Biophysik GmbH	Leipzig
Pharmaceutical	
APOGEPHA Arzneimittel GmbH	Dresden
AWD.pharma GmbH & Co. KG, Dresden	Dresden
elbion AG	Dresden
HEXAL Syntech GmbH	Dresden
Sächsisches Serumwerk Dresden (GlaxoSmithKline)	Dresden
Leipziger Arzneimittelwerk	Leipzig
Chemical	
Dow Chemical	Böhlen
Air Liquide GmbH Region Ost	Böhlen
Eurofoam Deutschland GmbH	Burkhardtsdorf
Linde-KCA-Dresden GmbH	Dresden
AWD.pharma GmbH & Co. KG	Dresden
Raschig GmbH Werk Espenhain	Espenhain
Siltronic AG Werk Freiberg	Freiberg
B.U.S Zinkrecycling Freiberg GmbH & Co. KG	Freiberg
Wacker-Chemie AG, Werk Nünchritz	Nünchritz
BASF Schwarzheide GmbH	Schwarzheide

Florena Cosmetic GmbH	Waldheim
Manufacturing Systems Engineering/Machine Building	
AWEBAWerkzeugbau GmbH Aue	Aue
Siemens VDO Mechatronic GmbH & Co. KG	Chemnitz
A. Friedr. Flender AG, Getriebewerk Penig	Chemnitz
NILES-SIMMONS Industrieanlagen GmbH	Chemnitz
USK Karl Utz Sondermaschinen GmbH	Chemnitz
StarragHeckert GmbH	Chemnitz
Sitec Industrietechnologie GmbH	Chemnitz
KARLMAYER Malimo Textilmaschinenfabrik GmbH	Chemnitz
VEM Sachsenwerk GmbH	Dresden
Linde-KCA-Dresden GmbH	Dresden
VON ARDENNE Anlagentechnik GmbH	Dresden
THEEGARTEN-PACTEC GmbH & Co. KG	Dresden
Glatt Systemtechnik GmbH (GST)	Dresden
Koenig & Bauer AG, Werk Radebeul	Dresden
Heidelberg Postpress Deutschland GmbH, Werk Leipzig	Leipzig
MAN TAKRAF Fördertechnik GmbH	Leipzig
EMAG Leipzig Maschinenfabrik GmbH	Leipzig
Neue ZWL Zahnradwerk Leipzig GmbH	Leipzig
Profiroll Technologies GmbH	Leipzig
TRUMPF Sachsen GmbH	Ostsachsen
MAN Roland Druckmaschinen AG, Werk Plauen	Plauen
Werkzeugmaschinenfabrik VOGTLAND GmbH	Plauen
Mikroelectronics and Application of Microelectronics	
KOMSAKOMMUNIKATION SACHSEN AG	Chemnitz
Infineon Technologies Dresden	Dresden
AMD Saxony Limited Liability Company & Co. KG	Dresden
SAPSystems Integration AG	Dresden
Atmel Germany GmbH, Design Center Dresden	Dresden
PRETTLElektronik Radeberg GmbH	Dresden
ZMD AG (Zentrum Mikroelektronik Dresden)	Dresden
VON ARDENNE ANLAGENTECHNIK GMBH	Dresden
Advanced Mask Technology Center GmbH & Co. KG	Dresden
FEPFAHRZEUGELEKTRIK PIRNAGMBH	Dresden
Deutsche Solar AG	Freiberg
SILTRONIC AG, Werk Freiberg	Freiberg
AB Elektronik Sachsen GmbH	Freiberg, Dresden
PC-Ware Information Technologies AG	Leipzig
LINTEC Information Technologies AG	Leipzig
BuS Elektronik GmbH & Co. KG	Riesa

*concerning this table it is key to note that it lists the largest companies (by employment and turnover) in R&D intensive industries – due to a lack of available data it is not directly possible to indicate the firms with the highest expenditure for R&D, of which some may be missing

Annex 4: RTD policies

National Level Policies:

Title of the measure or initiative: "Entrepreneurial Regions" – The BMBF Innovation Initiative for the New German Länder (Unternehmen Region)

Objectives:
The programme supports regional network alliances in the new German states (Länder) since 1999 with the aim to establish regional clusters. The initiatives being supported have to build on regional competences and innovation potentials in a strategic manner and according to entrepreneurial criteria. The programme aims to promote co-operations from which real competence clusters can develop, i.e. those including activities on a high technological level.
The overall rationale behind the programme is:

- to develop more regions with competitive business and science profiles,
- to promote the successful founding of innovative companies,
- to halt the migration of young experts to the western states and
- to create attractive development opportunities for talented young scientists

Policy Area:
Networking, co-location and clustering measures, Research Collaboration of Public Research Organisations with the Private Sector, Development of human capital

Main instruments and structure:
The Federal Ministry of Education and Research (BMBF) has set aside a total budget of around EUR 500 million for this programme for the period from 1999 to 2007.
The support funds provide subsidies to regionally anchored networks that develop entrepreneurial visions for their regions which are based on close, market-oriented cooperation between regional partners. The general objectives are pursued through five sub-programmes that focus on different aspects of regionally anchored networks such as inter-firm R&D co-operation, university-industry co-operation, qualification etc.

Main beneficiaries /target group:
Regional alliances developing their own future-proof technological profile and consistently exploiting and expanding the strengths and potentials of their region.

Achievements or failures *(why it is an example of good practice or a failure)***:**
In Saxony 39 Networks of Private Enterprises and Public Research Organisations have been established. The different policy sub-fields target different stages of the innovation process

- sub-programme InnoRegio (7 networks in Saxony)
- sub-programme Innovative Regional Growth Cores (8)
- sub-programme Centres for Innovation Competence (2)
- sub-programme Interregional Alliances for Tomorrow's Markets - Innovation Forums (9)
- sub-programme InnoProfiles (13)

The most recent programme evaluation for InnoRegio (BMBF, 2005) comes to a very positive conclusion based on the comprehensiveness of the programme and the combination of a regional and a networking approach that was well received by the participants.
However, it also notes that the comprehensiveness of the programme entailed a certain overcomplexity of the application process has and created overlaps with other government support programmes, that should be borne in mind when the programme will be developed further in the future.

Regional Level Policies:

Title of the measure or initiative: Regional Cluster Initiatives (e.g. Silicon Saxony, Biosaxony, Nanotechnology Cluster)
Objectives: To kick start cluster development in areas where Saxony has dormant potential and that are not yet fully occupied by other regional centres of excellence on the national level.
Policy Area: Networking, collocation and clustering measures
Main instruments and structure: Major investments in the extension or the new set-up of Public Research Facilities as well as in Technology Parks and Incubators oriented towards a certain industry. Initiation of industry networks to improve the communication among and to unit the actors in the private sector to develop a regional identity. Creation of stable links between the industry networks and public administration from the onset so as to speed and improve the administrative handling of the industries needs.
Main beneficiaries /target group: Public Research Organisations, Private Business Enterprises, Public Administration
Achievements or failures *(why it is an example of good practice or a failure)***:** The Saxon Government has been successful in identifying key industries of the future. Support of declining industries or industries without sufficient potential has been avoided. It has also been successful in adapting the needed support to the stage of cluster development. While sufficient support has been given at the early stages to kick-start development, the main focus has so far been moved to new fields of action in due time. Hence, policy attention has remained focused on nascent fields that need attention. Saxony has already succeeded in starting two more or less self-supporting clusters in rapid succession (Silicon Saxony, Biosaxony) with the third project now underway (Nanotechnology Cluster).

Title of the measure or initiative: SMWA Regional Support for Co-operative R&D Projects
Objectives: Improve university-industry and public research-industry relations in the region. Leverage the existing regional knowledge creation potential in the government sector for the business enterprise sector.
Policy Area: Research collaboration of public research organisations with private sector
Main instruments and structure: Industrial R&D in companies receives direct subsidies of up to 70% of project cost in SME and of up to 55% of project cost in other enterprises. Pre-competitive research, in contrast, receives only 45% support in SME and 30% in other enterprises. In case a public research organisation is involved as a partner, the support quotas can be raised by 5%. To encourage them to participate in industry driven projects, public research organisations themselves can receive support of up to 100% of project cost.
Main beneficiaries /target group: Companies from Saxony. The application process is open to firms from all industries and of all sizes (taking into account the different support quotas, see above). However, the SMWA is monitoring application activity based on its aim to support certain key industries to be able to capture new trends in regional RTDI.
Achievements or failures: Important open complement to the focused cluster initiatives catering for the needs of other innovators in Saxony that are active outside the focal sectors yet contribute substantially to regional innovative potential. Adequate use made of EU funding and national cross-subsidies. Serves to boost the level of innovative activity in Saxony particularly since application procedures are relatively easy.

Title of the measure or initiative: SMWA Individual Project Support
Objectives: Encourage R&D – particularly business sector R&D in the Region
Policy Area: Financial R&D measures for the private sector
Main instruments and structure: The measure is based on direct financial subsidies. Industrial R&D receives direct subsidies of up to 65% of project cost in SME and of up to 45% of project cost in other enterprises. Pre-competitive research, in contrast, receives only of up to 40% support in SME and of up to 20% in other enterprises.
Main beneficiaries /target group: Companies from Saxony. The application process is open to firms from all industries and of all sizes (taking into account the different support quotas, see above). However, the SMWA is monitoring application activity based on its aim to support certain key industries to be able to capture new trends in regional RTDI.
Achievements or failures: Important open complement to the focused cluster initiatives catering for the needs of other innovators in Saxony that are active outside the focal sectors yet contribute substantially to regional innovative potential. Adequate use made of EU funding and national cross-subsidies. Serves to boost the level of innovative activity in Saxony particularly since application procedures are relatively easy.

Title of the measure or initiative: Technology Park & Incubator Support, Support for External Industrial Research Associations, Technology Transfer Centre & IPR Consulting Centre Support
Objectives: Originally: Keep researchers in the region that had been laid off in the context of transformation Today: Improve technology transfer and encourage technology start-ups
Policy Area: Knowledge and Technology Transfer to industry and creation of an innovation friendly environment
Main instruments and structure: Technology Parks and Incubators can be subsidised with up to 60% of project costs and general costs of operation. In selected disadvantaged regions, subsidies can cover up to 75% of running expenses. The general ceiling for support to individual units is set at EUR 200.000. External Industrial Research Associations have received considerable support in the past which was separated into support for investment and support for running expenses. This support, however, will be phased out in the coming years.
Main beneficiaries /target group: Technology Parks and Incubators, External Industrial Research Associations, Technology Transfer Centres and IPR Consulting Centres
Achievements or failures *(why it is an example of good practice or a failure)***:** Policy has generally been beneficial to maintain the innovative potential of the region during the phase of transformation and has served to provide a basis of new developments afterwards. However, is has remained a subject of debate whether too much funding has been allocated to inept infrastructure. Studies have suggested that a better focus on certain issues and key industries or simply a smaller number of units could have helped to allocate funding more efficiently. The policy can thus be characterised as a necessary complement but not as a full-fledged success in itself.