

Research and Development



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Volume 5

October 7, 2015
ISSN 0012-1304

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HLTW Übersetzungen GbR

Layout and Composition

eScriptum GmbH & Co KG, Berlin

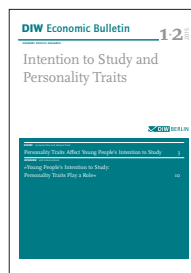
Press office

Renate Bogdanovic
Tel. +49-30-89789-249
presse@diw.de

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NEXT ISSUE OF DIW ECONOMIC BULLETIN

Public investment at the local level in Germany

Structural differences at the root of East-West Gap in research, development, and innovation in Germany

By Alexander Eickelpasch

Over the past two decades, research and development (R&D) activities in eastern Germany have increased substantially, albeit to a lesser extent than in western Germany. Furthermore, R&D in eastern Germany was primarily conducted by research in the government sector and less so by universities and businesses. In 2013, overall, R&D activities in eastern Germany reached 86 percent of the western German level; in the private sector, eastern Germany reached just under 50 percent of the western German level. The comparatively low level of R&D activity in eastern Germany's private sector is due to the economic and corporate structure: compared to the western German average, in eastern Germany the research-intensive sectors are not as well established and there are also fewer larger enterprises that generally perform a higher percentage of R&D work than smaller ones. The number of new products launched by companies as a share of the turnover is far lower than for western German firms, and this gap was found to further increase in recent years. Although the German government continues to grant a certain "east bonus" in its backing of private-sector R&D, structural differences will mean that no noticeable convergence towards the western German level can be expected in the near future. Significant regional differences in private-sector R&D activities have also been observed in western Germany.

To ensure successful economic development, a region needs efficient research and development (R&D) capacities and innovative enterprises. It is therefore not surprising that a number of studies on eastern Germany as a center for research have been published since reunification. For instance, DIW Berlin and the Donors' Association for German Science (*Stifterverband für die Deutsche Wissenschaft*), took up this issue as early as 1993.¹ The regional innovation system in eastern Germany has also been the subject of so-called progress reports by various economic research institutes,² reports by the Federal Ministry of Education and Research (BMBF) on Technological Performance, as well as by the Commission of Experts for Research and Innovation (EFI), most recently in 2010.³ Several studies on the innovation system in eastern Germany have analyzed funding programs for promoting innovation.⁴ Another recent study published

1 SV-Gemeinnützige Gesellschaft für die Deutsche Wissenschaft, Forschung u. Entwicklung in der Wirtschaft, Ergebnisse 1991, Eckdaten 1992, Planung 1993 (Essen: 1993). K. Hornschild, "Zur Situation der außeruniversitären und industriellen Forschung in den neuen Bundesländern," DIW Wochenbericht, no. 44 (1993): 643-648.

2 DIW, Kiel Institute for the World Economy (IfW), "Gesamtwirtschaftliche und unternehmerische Anpassungsprozesse in Ostdeutschland," 3rd report, Kiel Discussion Papers (Kiel: 1991): 176. DIW, Kiel Institute for the World Economy (IfW), and the Halle Institute for Economic Research (IWH), "Gesamtwirtschaftliche und unternehmerische Anpassungsfortschritte in Ostdeutschland," 14th report, Kiel Discussion Papers (Kiel: 1996): 277/278. DIW, Kiel Institute for the World Economy (IfW), and the Halle Institute for Economic Research (IWH), "Gesamtwirtschaftliche und unternehmerische Anpassungsfortschritte in Ostdeutschland," 19th report, Kiel Discussion Papers (Kiel: 1999): 346/347. DIW, The Research Institute of the Federal Employment Agency (IAB), Kiel Institute for the World Economy (IfW), Halle Institute for Economic Research (IWH), and the Center for European Economic Research (ZEW), "Zweiter Fortschrittsbericht wirtschaftswissenschaftlicher Institute über die wirtschaftliche Entwicklung in Ostdeutschland," IWH-Sonderheft 7 (Halle/Saale: 2003).

3 J. Günther et al., "20 Jahre nach dem Mauerfall: Stärken, Schwächen und Herausforderungen des ostdeutschen Innovationssystems heute," Studien zum deutschen Innovationssystem, no. 17 (Halle/Saale: 2010a).

4 For example H. Belitz, F. Fleischer, and A. Stephan, "Staatliche Förderung von Forschung und Entwicklung in der ostdeutschen Wirtschaft – Eine Bilanz," DIW Wochenbericht 68 (35): 537-544. D. Czarnitzki and G. Licht, "Additionality of public R&D grants in a transition economy. The case of Eastern Germany," *Economics of Transition*, vol. 14 (1) (2006): 101-131. K. Koschatzky and V. Lo, "Innovationspolitik in den neuen Ländern. Bestandsaufnahme und Gestaltungsmöglichkeiten," (Karlsruhe: 2005). A. Eickelpasch et al., "Bedeutung von FuE für die Entwicklung des verarbeitenden Gewerbes in Ostdeutschland und Wirkungen der technologieoffenen Programme zur Förderung der Industrieforschung," Politikberatung kompakt 58 (Berlin: 2010).

Box 1

Data sources

According to the standard international definition in the OECD Frascati Manual,¹ research and experimental development (R&D) comprises creative work undertaken on a systematic basis in order to increase the stock of human knowledge and to devise new applications based upon it. Data on R&D are generally captured using two indicators: R&D employees (calculated as full-time equivalents) and R&D expenditure. R&D employees include researchers, technical personnel, and any other employees that are directly related to the field of R&D, while R&D expenditure covers all internal human resources and fixed asset costs, as well as any investment associated with research and development activities. Furthermore, according to international convention, R&D activities are also categorized according to whether they are conducted in the private sector (in businesses and enterprises), in universities, or in other public institutes (government sector).

In Germany, the *Stifterverband für die Deutsche Wissenschaft* (SV) analyzes private-sector R&D activities directly at the

source using corporate data.² These data are collected for uneven reporting years in complete surveys. In the alternating years, R&D activities are recorded in a small survey among large-sized companies. Research and development activities at universities ("Higher education sector") and other public institutes ("Government sector") are surveyed by official statistical offices.³ The government sector is defined as all public research institutes (national, *Länder*, and local level), the publicly funded Helmholtz, Max Planck, and Fraunhofer institutes, Gottfried Wilhelm Leibniz institutes, the academies (as per the German Academies of Sciences and Humanities research program), as well as public and publicly funded research libraries, archives, information centers, and museums. Complete time series on public-sector R&D have only been available since 1995, when regular surveys on R&D employees were introduced for the first time.

¹ *Frascati Manual; Proposed Standard Practice for Surveys on Research and Experimental Development* (Paris: OECD, 2002).

² A. Kladroba, *a.rendi: FuE-Zahlenwerk 2015: Forschung und Entwicklung im Wirtschaftssektor 2013* (Essen: 2015).

³ "Ausgaben, Einnahmen und Personal der öffentlich und öffentlich geförderten Einrichtungen für Wissenschaft, Forschung und Entwicklung 2013," *Fachserie 14, Reihe 3.6*, ed. Federal Statistical Office (Destatis) (2013); "Bildung und Kultur. Monetäre hochschulstatistische Kennzahlen 2012," *Fachserie 11, Reihe 4.3.2*, ed. Federal Statistical Office (2014).

by Euronorm⁵ looks at eastern Germany only, making regional comparisons impossible. The present report, in contrast, focused on an east-west comparison of R&D activities within the German context as well as within the broader international context (see Box 1).

Public-sector R&D activities on a strong footing in eastern Germany with private sector lagging behind

In 1995, following rapid job cuts in the wake of reunification, just over 78,000 people were employed in the R&D sector in eastern Germany (including Berlin); the equivalent figures for the years immediately before (1989) and after reunification (1991) were 141,000 and 91,000 people, respectively.⁶ Until 2002, the employment figures

for R&D remained largely unchanged, reaching an unprecedented low at just under 74,000 people in 2005.

Ever since, however, employment in the R&D sector has been on the increase again, reaching one fifth of the 1995 level by 2013 (see Figure 1), a trend that is mainly attributable to research of the government sector. Immediately after reunification, R&D employment in this area initially decreased but recovered again in the early 2000s. Employment growth was strongest in the second half of the decade. In 2013, R&D employment was 43 percent above the 1995 level (see Table 1). Growth in R&D employment at universities, in contrast, was less than half of this figure. The lowest growth was seen in the private sector, reaching just six percent of the 1995 level. This resulted in a corresponding decrease in the private-sector share of total R&D employees (46 percent in 2000 compared with 37 percent in 2013).

Unlike the figures for R&D employment, R&D expenditure was on the increase even before the turn of the mil-

⁵ Konzack et al., *Zwischenbericht zur Studie. Wachstumsdynamik und strukturelle Veränderungen der FuE-Potenziale im Wirtschaftssektor Ostdeutschlands und der neuen Bundesländer: FuE-Daten 2011 bis 2013* (Berlin: 2014).

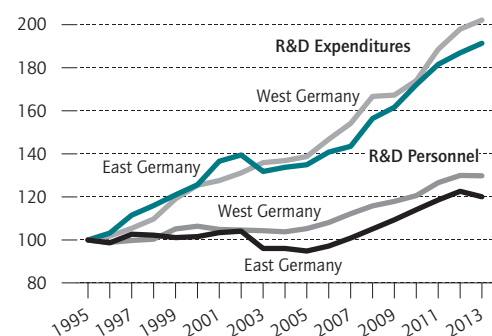
⁶ A. Eickelpasch, "Forschung, Entwicklung und Innovationen in Ostdeutschland," *Vierteljahrshefte zur Wirtschaftsforschung* 78 (2) (2009): 78–109. For details of the transition phase, see J. Günther et al., "20 Jahre nach

dem Mauerfall: Transformation und Erneuerung des ostdeutschen Innovationssystems," *Studien zum deutschen Innovationssystem* 16 (Halle/Saale: 2010b).

Figure 1

R&D personnel and R&D expenditures in East and West Germany

1995 = 100



Sources: Donors' Association for German Science, Federal Statistical Office, calculations by DIW Berlin.

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Since the mid-2000s the increase was in West Germany stronger than in East Germany.

lennium. Growth was particularly strong from 2008 onward, totaling 10.4 billion euros—or almost twice the 1995 level—in 2013. Similar to R&D employment, the main drivers of this positive development were also research by the government sector. R&D expenditure in

the private sector also increased, particularly at the beginning of the new millennium. Similar to R&D employment, the private-sector share of overall R&D expenditure has slowly declined (to just below 39 percent).

Despite the considerable improvement in R&D activities, eastern Germany still failed to close the gap to western Germany (see Figure 1). From 1995 to 2013, R&D employment in western Germany rose by 30 percent—an increase of ten percentage points compared to eastern Germany. Unlike in eastern Germany, the main drivers in western Germany were businesses and universities, although the differences between private and government sector were not as pronounced as in eastern Germany.

With regard to R&D labor intensity (ratio of R&D employees to the total workforce), eastern Germany attained 86 percent of the western German level in 2013 (see Table 2). Compared to the 1995 level, this is a substantial increase (79 percent); it does not, however, constitute much of an increase over 2010 (84 percent). The east-west gap is particularly apparent in the private research sector (48 percent). This is offset by research by the government sector whose R&D intensity is twice that of western Germany and by universities whose R&D intensity is one-third greater than that of western Germany. The private-sector east-west gap has remained virtu-

Table 1

R&D personnel and expenditures in East and West Germany

	2000	2005	2009	2011	2012	2013	1995	2000	2005	2009	2011	2012	2013
	1995 = 100						Structure in percent						
East Germany													
R&D personnel	102	95	109	119	123	120	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Business enterprise sector	111	91	102	111	114	106	41.8	45.7	39.9	38.9	39.1	38.9	36.9
Higher education sector	94	91	107	113	118	119	31.5	29.1	30.4	30.9	30.0	30.4	31.4
Government sector	96	106	124	138	141	143	26.6	25.2	29.7	30.2	30.9	30.7	31.7
R&D expenditures	126	135	162	182	187	191	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Business enterprise sector	142	143	157	172	181	181	41.1	46.4	43.6	40.0	39.0	39.9	38.9
Higher education sector	109	118	147	171	175	184	28.8	25.0	25.2	26.2	27.1	26.9	27.7
Government sector	119	140	182	204	206	212	30.1	28.6	31.2	33.8	33.9	33.2	33.4
West Germany													
R&D personnel	106	105	118	127	130	130	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Business enterprise sector	110	110	119	128	132	130	65.9	68.2	68.6	66.6	66.6	66.7	65.9
Higher education sector	102	95	118	127	130	132	20.0	19.2	18.0	19.9	20.0	20.0	20.4
Government sector	95	100	112	120	122	126	14.2	12.6	13.4	13.5	13.4	13.3	13.8
R&D expenditures	125	139	167	189	198	202	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Business enterprise sector	132	144	170	192	202	201	70.8	74.4	73.6	71.9	72.1	72.4	70.5
Higher education sector	112	128	169	191	199	221	16.1	14.4	14.9	16.3	16.4	16.2	17.7
Government sector	107	121	151	166	173	182	13.1	11.2	11.4	11.8	11.5	11.4	11.8

Sources: Donors' Association for German Science, Federal Statistical Office, calculations by DIW Berlin.

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R&D in the eastern German business sector has only slightly expanded.

Table 2

R&D intensity in East Germany

	1995	2000	2005	2009	2011	2012	2013	1995	2000	2005	2009	2011	2012	2013
	R&D intensity							R&D intensity (West Germany = 100)						
East Germany														
R&D personnel	10.1	10.4	10.2	11.2	12.1	12.4	12.2	79	83	82	84	85	87	86
Business enterprise sector	4.2	4.8	4.1	4.4	4.8	4.9	4.5	50	56	48	49	50	51	48
Higher education sector	3.2	3.0	3.1	3.5	3.7	3.8	3.8	125	125	138	130	129	133	132
Government sector	2.7	2.6	3.1	3.3	3.6	3.8	3.8	149	165	183	191	195	198	200
R&D expenditures	1.9	2.2	2.2	2.4	2.5	2.5	2.5	85	89	88	85	86	84	84
Business enterprise sector	0.8	1.0	0.9	0.9	1.0	1.0	1.0	49	56	52	47	47	47	47
Higher education sector	0.5	0.5	0.5	0.6	0.7	0.7	0.7	151	155	149	137	142	140	132
Government sector	0.6	0.6	0.7	0.8	0.8	0.8	0.8	195	228	240	243	253	244	238

R&D personnel as percentage of total employees (ESVG 2010). R&D expenditures as percentage of total value added (ESVG 2010).

Sources: Donors' Association for German Science, Federal Statistical Office, calculations by DIW Berlin.

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R&D intensity in eastern Germany business sector is behind western Germany, and has a lead in the government and higher-education sector.

ally unchanged since 2003, while the government sector is increasing its lead once again. With regard to R&D intensity (expenditure as a percentage of GDP) the relationship between eastern and western Germany is similar to that for R&D labor intensity.

Neither western nor eastern Germany is homogeneous in economic terms or with regard to R&D activities. At 73 percent, the R&D labor intensity of eastern German area states (*Flächenländer*), for example, is still lagging further behind that of western Germany than it would if the city state of Berlin were included. The R&D intensity of Berlin is exceeded by one state only: Baden-Württemberg (see Figure 2). Saxony and Thuringia—the two leading area states in eastern Germany in terms of R&D intensity—display higher figures than a number of western German states (Saarland or Schleswig-Holstein). As far as private-sector R&D capacity is concerned, the situation is very different. In this area, Berlin—the most important eastern German industrial R&D location in terms of intensity—ranks behind Baden-Württemberg, Bavaria, Hesse, and Lower Saxony, and is approximately on a par with Hamburg and North Rhine-Westphalia.

In an international comparison of R&D activities, eastern Germany does not fare too badly. The R&D intensity is a little over the EU average, and the situation in eastern Germany is far better than most Central and Eastern European Countries (CEECs) such as Hungary, the Czech Republic, Poland, or Slovakia (see Figure 3). The R&D intensity in eastern Germany even surpasses that of some western European countries (UK, Italy, Spain, and Portugal). Here, too, a different picture emerges if

the R&D intensity of the private sector only is examined. In this case, eastern Germany is below the EU average.

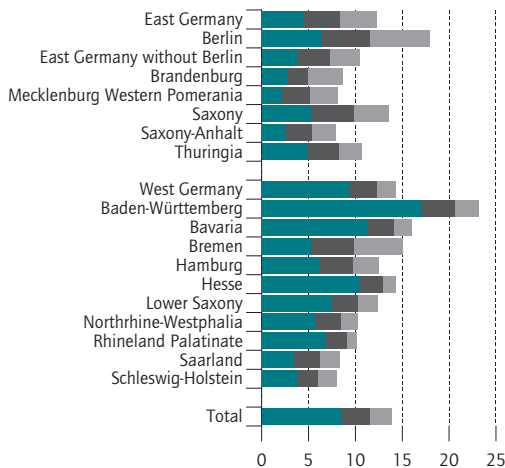
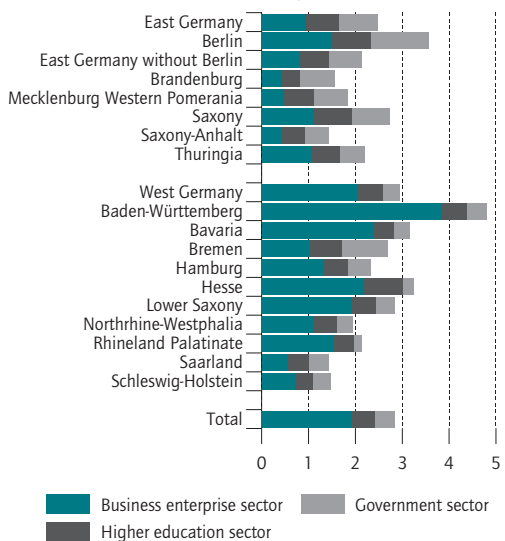
The competitive edge that eastern Germany has owing to its strong position in the area of public and university-based R&D is not insignificant. This region consequently has a good basis for the development of a truly competitive regional economy. For this to happen, however, businesses have to want to and be able to exploit existing potential. What must also be borne in mind is that the R&D activities of universities and the government sector are not always economically viable and are tailored toward the needs of the regional economy.

Research-intensive industries ...

One reason for eastern Germany's lack of private-sector R&D activities is that there are fewer research-intensive industries in eastern Germany than in western Germany. In 2014, around 39 percent of employees subject to social security contributions in the manufacturing industry in eastern Germany were employed in research-intensive sectors, predominantly mechanical engineering, while the equivalent figure for western Germany was 51 percent, the main focus here being the automotive industry, one of Germany's most research-intensive sectors (see Table 3).

The differences in economic structure are not the sole reason for eastern Germany's weaker position in private-sector research and development. The R&D intensity in eastern Germany is not only lower than in western Germany in the manufacturing industry as a whole, but also in individual key sectors (see Table 4). The gap

Figure 2

R&D Intensity by Federal States 2013**R&D personnel as percentage of total employees*****R&D expenditures as percentage of total value added***

* ESVO 2010.

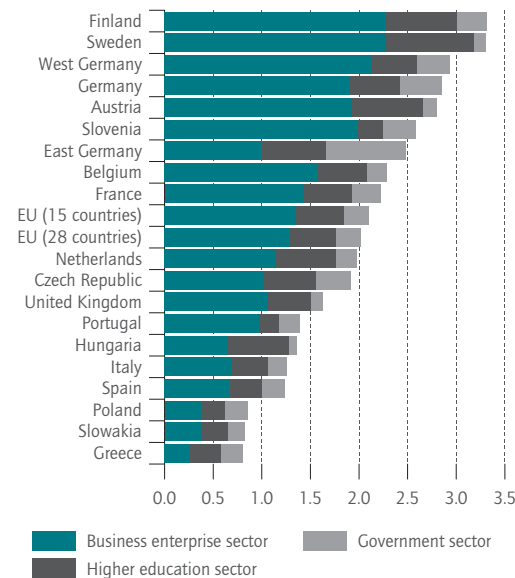
Sources: Donors' Association for German Science, Federal Statistical Office, calculations by DIW Berlin.

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Large regional differences within East Germany and also in comparison with federal states in West Germany.

is particularly pronounced in the chemical industry and the automotive sector, while it is not quite as marked in the mechanical, electrical, and optical engineering sectors. The rather weak position of industrial R&D in eastern Germany is put into perspective when one considers the fact that industrial research in eastern Germany is sometimes conducted by independent institutes which fall into the service sector category in official statistics (see Box 2).

Figure 3

R&D expenditures as percentage of total value added 2013 in East Germany compared to other European countries

Sources: Eurostat, Donors' Association for German Science, Federal Statistical Office, calculations by DIW Berlin.

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East Germany is due to the high government R&D above EU average.

... and major companies poorly represented in eastern germany

Another reason for the limited R&D activities in eastern Germany is the relatively low number of larger companies that perform more R&D than smaller firms on average.⁷ Employment statistics show that the number of industrial enterprises with more than 249 employees in eastern Germany increased by almost 13 percent between 2008 and 2013, while in western Germany the figure remained relatively stable. The differences are, however, still very significant: in 2014, one-third of industrial employees in eastern Germany worked for industrial enterprises with 250 or more employees, compared with over half in western Germany (see Table 5). In companies with 500 and more employees, the employee figures for western Germany were twice that of eastern Germany.

⁷ According to cost structure statistics, more than two-thirds of industrial enterprises with 500 and more employees conducted R&D in 2013: in the case of companies with 20 to 49 employees and those with 50 to 99 employees the equivalent figures were just 13 and 24 employees, respectively. See: A. Eickelpasch, "Research and Development in Manufacturing: Companies Performing Better than Ever," DIW Economic Bulletin, no. 31 (2015): 703.

Table 3

Employees subject to social insurance contributions in East and West Germany by branches

In percent

	East Germany			West Germany		
	2013 compared to 2008	Structure 2008	Structure 2014	2013 compared to 2008	Structure 2008	Structure 2014
Business sector	6.2	100.0	100.0	5.6	100.0	100.0
Manufacturing	3.2	24.6	23.9	-0.3	33.6	31.6
<i>Structure in manufacturing</i>	x	100.0	100.0	x	100.0	100.0
<i>R&D-intensive branches</i>	5.1	38.5	39.2	1.9	49.5	51.0
<i>Chemical products</i>	1.2	3.7	3.6	-6.8	5.2	4.8
<i>Pharmaceutical products</i>	17.2	1.9	2.2	24.4	1.7	2.1
<i>Data processing equipment, electronic and optical products</i>	-1.0	7.1	6.7	-4.4	6.7	6.4
<i>Electrical products</i>	3.7	5.5	5.5	0.9	5.2	5.3
<i>Mechanical engineering</i>	4.8	11.2	11.4	2.6	15.4	16.0
<i>Manufacture of motor vehicles, trailers and semi-trailers</i>	12.6	6.4	7.2	3.5	13.4	14.2
<i>Manufacture of other transport equipment</i>	4.4	2.7	2.7	12.2	2.0	2.3
<i>Other manufacturing branches</i>	2.0	61.5	60.8	-2.5	50.5	49.0
Business services	7.2	75.4	76.1	8.5	66.4	68.4
Other branches in business sector	0.9	26.4	18.6	4.9	15.6	15.3
<i>Memo:</i>						
Employees in manufacturing (1,000)	x	880	918	x	5,648	5,695
Employees in business sector (1,000)	x	3,571	3,846	x	16,810	18,020
Share of employees in business sector on all employees (Percent)	x	68.4	67.7	x	75.6	73.6

Due to data revision, the values for 2014 are not fully comparable with previous years.

Sources: Data on employees subject to social insurance contributions, calculations by DIW Berlin.

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The research-intensive industries are still weaker represented in eastern Germany than in western Germany.

Table 4

R&D personnel as percentage of employees subject to social insurance contributions

	2009		2011		2013	
	East Germany	West Germany	East Germany	West Germany	East Germany	West Germany
Manufacturing total	2.3	4.6	2.5	4.9	2.4	4.9
R&D-intensive branches	4.7	8.2	5.2	8.7	4.9	8.6
Chemical products	3.9	7.1	3.3	7.3	3.1	7.5
Pharmaceutical products	7.1	18.5	9.4	17.8	12.3	13.8
Data processing equipment, electronic, optical and electrical products	7.6	8.4	8.1	9.4	7.6	10.3
Mechanical engineering	3.6	4.0	3.5	4.3	3.1	4.3
Vehicle manufacturing	2.0	11.7	3.3	12.0	2.7	11.2
Other branches in manufacturing	0.4	1.2	0.7	1.2	0.7	1.2

Sources: Donors' Association for German Science, data on employees subject to social insurance contributions, calculations by DIW Berlin.

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R&D intensity is lower in eastern Germany research-intensive industries than in western Germany.

Box 2

Structure of industrial R&D in eastern Germany

In eastern Germany, 62 percent of R&D employees work in industrial enterprises—compared with 85 percent in western Germany. The IT and communications technology (ICT) and company-oriented services sectors, however, also play a relatively large role in eastern Germany's R&D landscape. In fact, service enterprises from the field of research and technology account for 21 percent of overall R&D employment in eastern Germany—three times as much as in western Germany (see Table). One of the reasons for this difference is the significance of non-profit industrial research institutes (IRIs) which are specific to the eastern German innovation system. Most non-profit IRIs came about as a result of 1991 resolution of the *Treuhandanstalt* or Trust Agency, a public privatization agency whose task it was to privatize, reorganize or, if necessary, liquidate the former state assets of the GDR; according to this resolution, the R&D capacity of the combines—and in some cases of universities and the GDR Academy of

Science (*Akademie der Wissenschaften der DDR*)—was to be outsourced.¹ Similar to non-university institutions, non-profit IRIs develop applied technical solutions and conduct preliminary research for industrial enterprises; the difference, however, is that they receive no basic funding from the state for this. In 2009, the 64 non-profit IRIs in Germany employed approximately 2,640 people, 2,210 of whom were active in the field of R&D.² This equates to around two-fifths of the entire R&D workforce employed in eastern Germany's R&D sector. Around half of these non-profit IRIs are based in Thuringia or Saxony.

¹ K. Hornschild and A. Scherzinger, "Forschung und Entwicklung in Ostdeutschland," *DIW Wochenbericht*, no. 62 (6) (1995): 143–153.

² I. Lacasa et al., "Industrieforschung in Ostdeutschland: Welchen Beitrag leisten die externen Industrieforschungseinrichtungen?," *Wirtschaft im Wandel* 12 (2012): 344–350.

Table

R&D personnel and expenditures in the business enterprise sector

Structure in percent

	R&D personnel				R&D expenditures			
	2009		2013		2009		2013	
	East Germany	West Germany	East Germany	West Germany	East Germany	West Germany	East Germany	West Germany
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Manufacturing total	59.2	85.2	62.4	85.1	61.2	87.6	66.8	87.5
R&D-intensive branches	47.4	75.1	50.7	75.3	50.2	78.7	56.3	79.2
Chemical products	3.7	6.8	3.0	6.3	3.2	7.4	2.4	6.6
Pharmaceutical products	3.7	5.9	7.1	5.0	8.8	8.6	15.9	6.9
Data processing equipment, electronic, optical and electrical products	24.6	18.3	24.6	20.8	22.9	15.2	22.9	17.3
Mechanical engineering	10.7	11.5	9.1	11.9	9.6	10.0	7.4	10.3
Vehicle manufacturing	4.7	32.6	6.9	31.3	5.6	37.6	7.6	38.2
Other branches in manufacturing	6.2	10.7	11.7	9.8	11.0	8.9	10.5	8.4
Information and communication	13.8	5.9	12.4	5.8	13.7	5.0	13.0	5.3
Freelance, scientific and technical services	23.0	6.6	21.3	6.7	21.0	5.2	17.5	5.0
Engineering activities; technical testing and analysis	6.7	2.9	6.1	2.9	5.8	2.1	4.7	2.1
Research and development	15.9	3.2	14.4	3.3	15.0	2.6	12.2	2.4
Other branches	4.1	2.3	3.9	2.4	4.1	2.2	2.8	2.1
Companies with ... employees								
to 49	26.8	3.9	27.1	5.0	18.2	2.3	15.7	2.6
50–249	26.1	8.9	24.4	8.3	21.3	6.3	16.4	5.3
250–999	11.9	13.6	9.9	14.9	12.6	11.0	10.2	11.0
1,000 and more	35.2	73.6	38.6	71.8	48.0	80.4	57.8	81.1
R&D employees (1000), R&D expenditure (bn Euros)	33.2	299.3	34.6	325.8	3.5	41.7	4.1	49.5

Sources: Donors' Association for German Science, calculations by DIW Berlin.

Table 5

Employees subject to social insurance contributions in East and West Germany in manufacturing by size of plants

In percent

	Total (1,000)	thereof in plants with ... employees								
		1-5	6-9	10-19	20-49	50-99	100-199	200-249	250-499	500 and more
East Germany										
2008	879.8	4.8	4.1	7.9	15.2	15.2	17.2	5.6	12.9	17.1
2013	907.8	4.4	3.6	7.3	14.5	14.7	17.3	5.6	14.0	18.6
2014	918.1	4.2	3.5	7.2	14.3	14.3	17.3	5.9	14.0	19.2
West Germany										
2008	5,648.1	3.4	2.8	5.3	9.8	9.9	12.4	4.4	14.4	37.7
2013	5,629.6	3.1	2.6	5.1	9.8	9.9	12.3	4.5	14.6	38.2
2014	5,694.6	3.0	2.6	5.0	9.7	9.9	12.3	4.5	14.4	38.8

Due to data revision, the values for 2014 are not fully comparable with previous years.

Sources: Data on employees subject to social insurance contributions, calculations by DIW Berlin.

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Large industrial companies have increased in importance in eastern Germany.

Accordingly, R&D in eastern Germany is conducted chiefly by small and medium-sized enterprises (SMEs or companies with up to 249 employees). In 2013, 51.6 percent of R&D employees in eastern Germany worked for SMEs, compared to just 13.3 percent in western Germany (see table in Box 2).

A certain east-west divide can also be seen within the individual company categories: according to the 2010 IAB Establishment Panel Survey conducted by the Institute for Employment Research, in the category “companies with 500 and more employees,” 29 percent of all industrial enterprises in eastern Germany perform R&D activities, compared to 52 percent in western Germany.⁸ A similar picture can be seen in medium-sized enterprises (250 to 499 employees), where far less R&D is conducted in eastern Germany than in western Germany (32 compared to 41 percent). In small-sized enterprises (fewer than 250 employees), in contrast, no differences are evident.

Far more patent applications and innovations in the west

Patents are one possible indicator of R&D output. Patents document preliminary findings in the innovative process that indicate new technological knowledge with the po-

tential to be economically viable.⁹ The present study analyzes sample patent applications submitted to the European Patent Office (EPO), which Eurostat, the statistical office of the European Union, has organized by region and inventor’s place of residence.¹⁰ According to these data, in eastern Germany, patent density—the number of patents per 100,000 residents—grew between 1995 and 2010, while in western Germany this figure remained virtually unchanged (see Figure 4). Nonetheless, in 2010, patent density in western Germany remained almost three times as high as in eastern Germany.

Not every new development is necessarily based on patents. Conversely, not every patent leads to an economically viable product development. In addition, it can take some time before a patent application results in new product developments. Thus, a more accurate way of as-

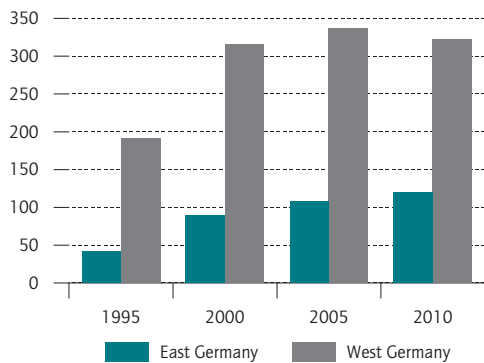
⁹ Patents can only function as indicators provided that new knowledge is submitted for patenting, which is not always the case. This is due to cost factors and organizational problems, especially in the case of small firms, as well as confidentiality issues. In addition, patents give no indication of the actual economic significance of an invention. In some instances, patented innovations are never intended to be introduced on the market (“blocking patents”). What must ultimately be borne in mind is that not every patent application is successful. Companies can retract an application and patent applications may be rejected.

¹⁰ In regional studies, patent applications are generally counted at the location of the applicant and not the location of the inventor to avoid regional distortions. This is important, since large companies in particular submit patent applications where their corporate HQ is, even if the research team is based somewhere entirely different. The patent applications published by the German Patent and Trademark Office (DPMA) by German state are retrievable on the basis of the applicant’s location only and not the inventor’s location.

⁸ M. Arnold et al., “Die ostdeutsche Wirtschaft ist zu kleinteilig strukturiert,” DIW Wochenbericht, no. 82 (35) (2015): 764–772.

Figure 4

Patent applications to the european patent office per 100,000 inhabitants



Sources: Eurostat, calculations by DIW Berlin.

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Patent applications are lower in East Germany than in West Germany.

Assessing the innovative strength of given enterprises or regions is to look at new products and services that have been launched (product innovations) as well as production methods and organizational procedures that have been optimized (process innovations). Here, data from the Mannheim Innovation Panel of the Center for European Economic Research (ZEW) were used. According to this survey, innovators are defined as companies that have completed innovation projects or launched an innovation in the three years prior to the survey (product or process innovations).¹¹

In 2013, at 42 percent, the innovation rate (the number of companies pursuing innovation activities as a proportion of the total number of companies) in the eastern German manufacturing industry was similar to that in western Germany (see Table 6). Interestingly, both in eastern and western Germany, this rate has been on the decline for some years now. Differences in regional development are not discernible here.

Having said that, innovation activities in eastern and western Germany are by no means comparable. In fact, as is the case with R&D expenditure, the actual regional difference lies in company or organization size. With an average of 64 employees, eastern German innovators are far smaller in size than their western German counterparts (133 employees). The prevalence of small-sized companies also explains why innovation spend-

Table 6

Companies with innovation activities in manufacturing and mining ("Innovators")

In percent

	1995	2000	2005	2009	2011	2013
Innovators (Share on all companies)						
East Germany	60	61	55	48	46	42
West Germany	55	62	59	50	47	44
Employees in innovators (Share on all employees)						
East Germany	71	76	73	67	65	59
West Germany	83	84	83	82	80	77
Employee per innovator						
East Germany	84	75	84	61	64	64
West Germany	173	158	162	116	128	133
Innovation expenditures (Share on turnover)						
East Germany	4.6	4.2	5.5	3.2	3.0	3.0
West Germany	4.4	4.4	4.9	4.8	4.3	4.6

Population: Enterprises with 5 or more employees; 2006 break in time series; 2013 preliminary.

Source: ZEW (Mannheim Innovation Panel).

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The innovation expenditures are lower in eastern German industrial companies than in western German industry.

ing¹² (in relation to the turnover) was lower in eastern Germany than in western Germany (3.0 percent as opposed to 4.6 percent in 2013), a gap that has in fact widened in recent years.

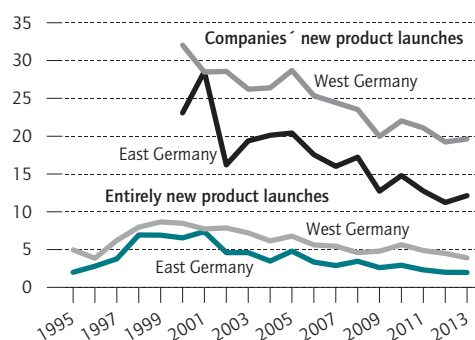
A company's product innovations are defined as new products that have been successfully launched onto the market or improvements to existing products, irrespective of whether these are entirely new products or ones that are already available from other manufacturers. The significance of these products is generally their share of the company's overall turnover. Similar to innovation expenditure, the "innovation success" in the manufacturing industry in eastern Germany is far lower than in western Germany (12 percent compared with 20 percent in 2013) (see Figure 5). Until the mid-2000s, this difference was largely stable, after which the discrepancy became even more apparent. In 2006, eastern German industry reached as much as 73 percent of the innovative product share of total turnover in western Germany; in 2010, this figure had dropped to 69 percent and by 2013, it was as little as 62 percent. A similar picture can be seen if the indicator "innovation success" is limited to the share of entirely new products (new product launches) of total turnover.

¹² Besides external and R&D costs, innovation expenditure includes investments in fixed assets and intangible goods as well as any other expenditure related to the production and marketing of innovations (design engineering and product design, product concept, training measures, and market launch). These costs thus give an indication of the extent to which companies also invest in the transfer of R&D findings to real applications and the introduction of new products to existing lines. See Rammer, "Innovationsverhalten," 4.

¹¹ C. Rammer et al., Innovationsverhalten der deutschen Wirtschaft: Indikatorenbericht zur Innovationserhebung 2014 (Mannheim: 2015): 3.

Figure 5

Share of new products on overall turnover in manufacturing and mining



Population: Enterprises with 5 or more employees; 2006 break in time series; 2013 preliminary.

Source: ZEW (Mannheim Innovation Panel).

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In innovation performance of East German industrial companies remain behind.

Very few dedicated eastern german R&D funding programs

During the transformation phase of the eastern German economy, which was largely complete by the mid-1990s, one of the main areas of focus was to safeguard existing R&D potential in the newly founded and privatized enterprises as well as in the research institutes. Under Section 28 of the Unification Treaty of 1990, the scope of R&D investment initiatives from the former West German states was extended to include the newly formed eastern German states (former GDR) and Berlin-Ost (loan and investment programs, initiatives by the German Federal Ministry of Education and Research (BMBF), industrial collective research). The German federal government also introduced specific conditions and dedicated funding schemes for eastern German SMEs.¹³ The economic administrative authorities in the new federal states also began backing regional industrial research, very often looking to the West as an example.

The majority of the government funding programs for R&D designed specifically for eastern Germany expired at the end of the transformation phase or in the second half of the 1990s. This did not, however, mean the end

¹³ Belitz, Fleischer, and Stephan, "Staatliche Förderung."

Table 7

Research-based companies with financial support for R&D and innovation

In percent

	Manufacturing 2009 ¹		Manufacturing 2013 ²		Services 2009 ¹		Services 2013 ²	
	East Germany	West Germany	East Germany	West Germany	East Germany	West Germany	East Germany	West Germany
Total (percent of all research-based companies)	47	19	52	36	37	19	47	23
Thereof (percent of all research-based companies with financial support)								
Federal states	59	38	37	28	63	41	35	35
Federal government	52	50	77	71	72	37	68	70
Federal Ministry of Economics and Energy	39	27	56	39	51	18	39	29
Federal Ministry of Education and Research	14	23	22	27	21	25	30	47
European Union	22	17	17	19	20	25	21	45

Research-based companies: Companies with continuous or occasional R&D.

¹ Share of research-based companies with financial support 2006 to 2008.

² Share of research-based companies with financial support 2010 to 2012.

Manufacturing: Manufacturing and Mining.

Services: WZ08 46, 49–53, 58–66, 69, 70.2, 71–74, 78–82.

Source: ZEW (Mannheim Innovation Panel).

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The "funding rate" has grown stronger in western Germany than in eastern Germany.

of financial assistance for eastern German industrial research.¹⁴ Indeed, some of the programs were continued in a different format, for example R&D personnel and R&D project funding under the auspices of the special R&D funding program for eastern Germany. Over the course of time, however, the focus of such initiatives changed. While at the outset the practice was to concentrate on bolstering R&D activities in enterprises and funding innovative start-ups, at the turn of the millennium the focus shifted toward knowledge transfer and networking.

The transfer of the technology-neutral innovation-oriented initiatives of the Federal Ministry for Economic Affairs and Energy (BMWi) to the Central Innovation Program for SMEs (*Zentrales Innovationsprogramm Mittelstand*, ZIM) in 2008 and the inclusion of western Germany in such initiatives marked a break with previous practices. Ever since, only very few initiatives have applied to eastern Germany only. These include the “Entrepreneurial Regions” initiative by the Federal Ministry for Education and Research and the funding program for East Germany “Innovation Competence East” (*Inno-Kom-Ost*) of the Ministry for Economic Affairs and Energy. In addition, more favorable conditions for eastern German SMEs were put in place as part of the ZIM Program for SMEs.¹⁵

Funding is very much taken advantage of in eastern Germany. According to the 2013 Mannheim Innovation Panel, 52 percent of eastern German industrial enterprises that conduct R&D activities received funding (“funding rate”) in the years 2010 to 2012 (see Table 9). The most important source of funding was the German government (77 percent of companies who received funding), in particular, funding programs of the Federal Ministry for Economic Affairs and Energy (56 percent). Funding at federal state or *Länder* level played a secondary role, although in 2009 the federal states provided funding more frequently than the German government. The extension of programs initially developed for eastern Germany to the whole country brought about a change in the attitude of western German enterprises towards funding, which is now similar to that of eastern Germany enterprises. The “funding rate” among western German research enterprises climbed from 19 (2009) to 36 percent (2013); the increase in eastern Germany was weaker by comparison (47 to 52 percent).¹⁶ The

proportion of eastern German service enterprises that received funding was slightly lower than was the case with eastern German industrial enterprises; the funding received was similarly distributed among the various funding bodies. The high level of funding is also evident in joint-funding: in 2013, 25.4 percent of R&D spending by funded enterprises in eastern Germany came from public funds. In the case of SMEs this figure was as much as 38.5 percent. Since 2010, however, this has fallen.¹⁷

In light of the poor development of private R&D activities in eastern Germany, one might very well ask how effective funding programs have been to date. Most evaluation studies as well as an analysis of the technology-neutral R&D funding programs for the manufacturing industry have largely produced positive results.¹⁸ According to these studies, R&D funding was instrumental in the advances made in eastern German industrial research, not least owing to support in the form of cooperation and partnerships, exchange of knowledge with public research institutes, and the stronger orientation towards the economic viability of R&D findings.

Conclusion

In the past few decades, R&D activities in eastern Germany have increased substantially. This development was, however, not quite as positive as in western Germany and was also concentrated on government sector. Eastern German universities and businesses, in contrast, enhanced their research and development activities little. In 2013, overall research and development intensity in eastern Germany reached 86 percent of the western German level. In the private sector, R&D intensity was just short of 50 percent. The reason for the comparatively low level of R&D activity in the private sector in eastern Germany is the economic and company structure: compared to the western German average, in eastern Germany there are fewer industrial enterprises that are active in the research sector and fewer larger enterprises that generally perform a higher percentage of R&D work than smaller companies.

In recent years, with the exception of the “Entrepreneurial Regions” and “Innovation Competence East” programs, the German government has extended funding programs formerly dedicated to eastern Germany

¹⁴ Günther et al., “20 Jahre nach dem Mauerfall.”

¹⁵ Deutscher Bundestag, “Bericht über die Programme zur Innovations- und Technologieförderung im Mittelstand in der laufenden Legislaturperiode, insbesondere über die Entwicklung des Zentralen Innovationsprogramms Mittelstand für die Jahre 2010 bis 2014”, German Bundestag printed paper no. 16/5058 (June 2, 2015).

¹⁶ Another reason could be the special grants for large enterprises awarded as part of the Central Innovation Program for SMEs (ZIM) during the 2008/

2009 crisis.

¹⁷ Konzack, “Wachstumsdynamik und strukturelle Veränderungen,” 87.

¹⁸ G. Untiedt, B. Alecke, and T. Mitze, *Stärkung des Forschungsstandortes Ostdeutschland durch steuerliche Anreize*, Bundesamt für Bauwesen und Raumordnung (Bonn: 2008); see also H. Belitz, A. Eickelpasch, and A. Lejpras, “Technology Neutral Public Support: An Important Pillar of East German Industrial Research,” DIW Weekly Report, no. 9 (2011): 2–10.

to include the whole of Germany, but it continues to grant a small “East bonus” in its technology-neutral funding program. Business R&D and innovation funding in eastern Germany is to continue to concentrate on interlinking knowledge potential in private enterprises, universities and research institutes in order to encourage small and medium-sized enterprises to make better use of the extensive public research infrastructure. Given the structural differences, it would be unrealistic to expect the east-west gap to close in the near future. An interesting observation here is the significant and long-lasting regional differences in econom-

ic structure and R&D activities prevalent in western Germany, too. With regard to government funding, the question that arises is whether innovation policy measures taken by the German government—including those that help tap into regional economic growth potential—should continue to be restricted to eastern Germany. The expansion of the funding scope of the Central Innovation Program for SMEs (ZIM) to all of Germany in 2008 was thus a step in the right direction. The goal now should be to achieve the same for any other innovation policy measures that presently apply to eastern Germany only.

Alexander Eickelpasch is Research Associate in the Firms and Markets Department of DIW Berlin | a.eickelpasch@diw.de

JEL: L25, O31, R11

Keywords: Regional innovation systems, Research and development (R&D), Small and medium sized companies, Manufacturing



Alexander Eickelpasch, Research Associate
in the Firms and Markets Department at
DIW Berlin

FIVE QUESTIONS TO ALEXANDER EICKELPASCH

»East-West Gap in private research, development, and innovation in Germany: Research-intensive industries and larger companies represented weakly«

1. Mr. Eickelpasch, after reunification, we saw a substantial increase in research and development, or R&D, activities in eastern Germany. How big is the gap between the east and the west of the country today? If we look at the number of R&D employees as a share of the total workforce in Germany, or what is known as R&D labor intensity, and R&D expenditure as a percentage of GDP, it becomes clear that eastern Germany is still lagging far behind western Germany. In terms of R&D intensity, the eastern German economy only reached around 50 percent of the western German level. The situation in public and publicly funded research institutes and universities looks much more favorable, however. R&D intensity in public and publicly funded institutions in eastern Germany is in fact twice that of western Germany.
2. What do the research findings reveal? Based on patent applications, it is apparent that research output in eastern Germany is still lagging far behind western Germany and the gap has shown no real sign of narrowing in recent years. The number of new products launched by companies as a share of their overall turnover is similarly weak in eastern Germany. This is an indicator of companies' innovative strength which shows that in eastern Germany, revenue from product innovations in the manufacturing industry is only 12 percent and the corresponding figure for western Germany 20 percent. In terms of the proportion of industrial products that are market innovations, the share of turnover accounted for by these products is 3.9 percent in western Germany and only 2.0 percent in the east.
3. Why was eastern Germany unable to catch up with the west, despite the strong expansion mentioned earlier? Simply because not every company needs to conduct research and not every company actually does conduct research. As a rule, R&D is conducted by what are known as research-intensive industries, which includes mechanical and automotive engineering as well as the chemical, pharmaceutical, electro technical, and electronics industries. These research-intensive sectors are not as well established in eastern Germany as they are in the west of the country. In eastern Germany, these industries account for 39 percent of manufacturing employment, whereas in western Germany the corresponding figure is over 50 percent. The other reason is that there are fewer larger companies in eastern Germany than in the west and these tend to invest more in R&D than smaller enterprises.
4. How stark is regional dispersion? It is important not to view eastern Germany as a homogenous region but rather to recognize that there is also relatively significant regional dispersion here, as there is in western Germany. One important region for research and development is the city state of Berlin, but the federal states of Saxony and Thuringia invest heavily in R&D, too. We can also see that in western Germany, the state of Schleswig-Holstein, for example, invests much less in research than Baden-Württemberg or Bavaria. Bearing this in mind, we should also take regional dispersion into account.
5. What can policy-makers do in order to drive research and development forward in eastern Germany? If we look at how policy programs have developed since reunification, we can see that in this field, since 2008, the German government has focused on harmonizing research and funding programs for the private sector. One example of this is the Central Innovation Program for SMEs or ZIM which has been open to companies in both western and eastern Germany since 2008. We should also not lose sight of the fact that innovation policy in Germany is a growth-based policy which is not intended to close regional development gaps. From this point of view, harmonizing funding conditions in 2008 was a step in the right direction. In our opinion, it would make sense to go even further and, once current funding programs specific to eastern Germany expire in 2020, the government should consider moving toward harmonization of funding conditions here, too.

Interview by Erich Wittenberg