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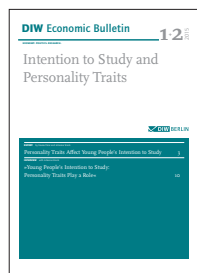
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## NEXT ISSUE OF DIW ECONOMIC BULLETIN

# Women, financial education, and financial behavior

# Private R&D not necessarily drawn to areas with high public R&D

By Alexander Eickelpasch

The bulk of Germany's research and development (R&D) activity is concentrated in densely populated areas, urban regions that account for 62 percent of the country's R&D workforce. The regions surrounding Stuttgart, Munich, and Braunschweig have by far the highest R&D intensity—that is, the share of R&D personnel in the total number of employees. Between 2003 and 2013, Munich lost some of its lead over the national average, while Stuttgart and Braunschweig increased their leads. In Germany on the whole, R&D personnel capacities in public research facilities and the higher education sector expanded more than did those in the business enterprise sector—not least due to the additional expenditure within the framework of certain government initiatives, namely the Pact for Research and Innovation, the German Universities Excellence Initiative, and the University Pact.

The areas with the highest R&D intensity in public research (that is, research facilities and institutes of higher education) are Göttingen, Dresden, and Aachen—but only Dresden was able to increase its lead during the observation period. In the private sector, Stuttgart, Braunschweig, Darmstadt, and Ingolstadt have the highest R&D intensities. For private R&D, spatial proximity to manufacturing plays a much stronger role than does proximity to public R&D—hence areas with lower levels of industrial activity should not only promote the transfer of knowledge within the region but also take advantage of public research conducted elsewhere in order to support the local economy. Furthermore, to make better use of knowledge potential at the local level, regional industry should be strengthened—for example, within the framework of industrial development policy.

In addition to supporting the domestic economy, institutes of higher education (henceforth referred to as IHE) and non-university research facilities make their surrounding areas attractive to foreign businesses and investors—that is, they are critical for regional development. They also serve as “antennae”<sup>1</sup> or “gatekeepers,”<sup>2</sup> organizations that gather and provide local businesses with extra-regional knowledge, thereby supporting the economy.

This interrelationship is of particular importance when it comes to economic policy, as R&D at the regional level has been gaining significance as a starting point for domestic innovation and research policy. Examples include the regionalized innovation policy of the Federal Ministry of Education and Research (BMBF) within the framework of the Entrepreneurial Regions program (*Unternehmen Region*), the expansion of East Germany's Innovations Forum (*Innovationsforen*) into West German regions, the new funding initiative *Innovative Hochschule*, and the restructuring of the intergovernmental commission *Verbesserung der regionalen Wirtschaftsstruktur*,<sup>3</sup> which promotes a higher level of regional innovation potential. There are also the long-running programs administered by the individual *Bundesländer* that encourage regional knowledge transfer.

Differentiated large-scale analyses on the current state and development of R&D facilities are not presently available at the regional level. The most recent comprehensive surveys, which were conducted by the *Stifterverband für die Deutsche Wissenschaft* (Association for the Promotion of Science and Humanities, SV), only encompass

<sup>1</sup> Michael Fritsch, Tobias Henning, Viktor Slavtchev, and Norbert Steigeburger, “Hochschulen als regionaler Innovationsmotor? Innovationstransfer aus Hochschulen und seine Bedeutung für die regionale Entwicklung.” Hans Böckler Foundation Working Paper 158 (2008), Düsseldorf.

<sup>2</sup> Holger Graf, “Gatekeepers in regional networks of innovators.” *Cambridge Journal of Economics* 35 (2011), 173–98.

<sup>3</sup> Federal Ministry for Economic Affairs and Energy (BMWi), “Koordinierungsrahmen der Gemeinschaftsaufgabe ‘Verbesserung der regionalen Wirtschaftsstruktur’.” August 4, 2016 onward, Berlin.

private sector R&D;<sup>4</sup> an older DIW Berlin study is limited to industrial R&D.<sup>5</sup> The Baden-Württemberg Statistical Office's latest survey only includes data on the state's local regions.<sup>6</sup> And lastly, although Eurostat does provide data broken down by region, it only does so on a very coarse spatial grid.<sup>7</sup>

This report aims to identify a relationship between the locations of public/IHE and private R&D activities. To that end, we analyze:

- the R&D capacities of individual regions and how they compare with the rest of the country
- which regions have an especially high concentrations of public research activities and thus offer a location advantage for private research
- the significance of the spatial relationship between private and public R&D activities.

The data basis is information on R&D personnel in the sectors *business enterprise (Wirtschaft)*, *government (Forschungseinrichtungen, research facilities)*,<sup>8</sup> and *higher education (Hochschule)* from the Organization for Economic Co-operation and Development (OECD) as well as the national accounts. Additional information that transcends the scope of the OECD statistics comes from data on IHE applied third-party funding, which serves as a rough indicator of research performance. All data are then broken down according to the individual planning regions, or *Raumordnungsregionen (RORs)*, that are used for large-scale analyses (see Box). The analysis period runs from 2003 to 2013.

### R&D capacities concentrated in urban areas

R&D activity is highly concentrated by region, with just two of the 96 RORs alone—Stuttgart and Munich—accounting for 19 percent of all R&D personnel. The eight regions with the next-highest concentrations—Berlin, Braunschweig, Heidelberg (official ROR name: Lower

#### Box

##### Data basis

R&D levels are ascertained using two indicators: the number of R&D personnel (measured as full-time equivalents, FTE) and the level of R&D expenditure.<sup>1</sup> *R&D personnel* encompasses scientists, technicians, and other employees directly connected to the field, while *R&D expenditure* includes all internal costs related to staff and materials as well as R&D investment. Data are then separated into three sectors as defined by the OECD: Business enterprise R&D, Government R&D (i.e. government units and non-market non-profit state-subsidized institutions; hereafter: research facilities R&D), and Higher education R&D (IHE).

In Germany, the SV collects private sector R&D data directly from businesses. For businesses with research facilities in separate locations, data on R&D personnel—but not on R&D expenditure—are taken. The data are calculated for odd-numbered report years and presented in the form of complete survey.<sup>2</sup>

Research facility R&D data are collected by the statistical offices.<sup>3</sup> Public R&D facilities include national, *Bundesländer*-run, and municipal research facilities; publicly funded organizations such as the Helmholtz-Zentrum, the Max Planck Society, the

1 OECD, "Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development." Paris (2015).

2 Andreas Kladroba, "FuE-Zahlenwerk 2015 – Forschung und Entwicklung im Wirtschaftssektor." Essen (2013).

3 Statistical Office, "Ausgaben, Einnahmen und Personal der öffentlichen und öffentlich geförderten Einrichtungen für Wissenschaft, Forschung und Entwicklung 2014." Fachserie 14 (2016), row 3.6.

4 Stifterverband Wissenschaftsstatistik GmbH, "Wo Unternehmen forschen – Verteilung und Veränderung." Essen (2016).

5 Alexander Eickelpasch, "The industrial innovation potential of the regions: Stuttgart and Munich further ahead." *DIW Weekly Report* 8, vol. 4 (2008), 49–57.

6 Baden-Württemberg Statistical Office, "Forschungs- und Entwicklungs-Monitor Baden-Württemberg." Series of statistical analyses, 02/2016, Stuttgart.

7 Due to a lack of data availability, NUTS 2 regions (basic regions for the application of regional policies) are generally used for European regional comparisons. In Germany, some of the NUTS 2 regions correspond to actual German *Bundesländer*, especially in East Germany; the rest of the NUTS 2 regions represent smaller units within each state. See European Commission, "Regional Innovation Scoreboard," 2016.

8 We use the term "research facilities" for this sector because the institutions analyzed here are primarily publicly funded non-university research institutions. See box.

Neckar), Frankfurt am Main (Rhine-Main), Cologne, Darmstadt (Starkenburg), Erlangen/Nuremberg (Middle Franconia), and Hamburg—account for just under 26 percent. All in all, the top 20 regions account for 62 percent of Germany's R&D capacities (Table 1).

To enable the comparison of regions of different sizes, each region's R&D intensity<sup>9</sup>—that is, the number of R&D employees relative to the total workforce—is measured. It turns out that most of the regions with large shares of Germany's R&D capacities are also significant business locations. For most of the 20 leading regions,

9 R&D personnel are identified by FTEs. Official employment statistics, however, provide only the number of employees—which means that R&D intensity is systematically underestimated.

Fraunhofer Society, the Leibniz Association, and the academies (according to academic program); and public and publicly funded scientific libraries, archives, science information centers, and museums.

Data on the R&D activities of IHE—including public and private universities, university hospitals, and projects and programs currently funded by the *Deutsche Forschungsgemeinschaft* (German Research Foundation)—are also collected by the statistical offices.<sup>4</sup> IHE R&D data can be divided into two categories: *basic research* and *third-party research*. *Basic research* is not measured directly; rather, it is estimated using the fixed working-time coefficients of the academic staff.<sup>5</sup> *Third-party research* includes all external funds collected and managed in IHE budgets, as well as information on the staff financed by these funds. One-third of all external funding comes from the German Research Foundation, one quarter comes from the federal government, and 14 percent comes from trade and industry.

The areas analyzed here are the 96 *Raumordnungsregionen* (ROR) defined and utilized by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (*Bundesinstitut für Bau-, Stadt- und Raumforschung*, BBSR) for large-scale

analyses in their ongoing spatial studies.<sup>6</sup> They roughly represent the functional socio-economic relations between a region's nucleus and surrounding area. As they are also *Bundesländer*, the city states of Berlin, Bremen, and Hamburg each constitute one self-contained ROR. The BBSR divides the RORs into three categories of settlement density (*Siedlungsstrukturellen Regionstypen*) according to density and the share of the population living in major or mid-sized cities: *urban* (24 RORs), *urbanizing* (35 RORs), and *rural* (37 RORs). Seventy-four RORs are located in West Germany, and 22 in East Germany. To make each region more immediately recognizable, we have replaced some of the more obscure official names with the name of the region's largest city (in this text, the official names appear in parentheses next to the common names).

The investigation is based on special evaluations by the SV and the Federal Statistical Office. In some regions, no data on public R&D activities can be recorded due to secrecy provisions;<sup>7</sup> estimates are used in these instances, but since this group comprises only very small regions, the estimates do not distort the results overall. Information on externally funded IHE personnel is only available from 2006 onwards.

<sup>4</sup> Statistical Office, "Bildung und Kultur: Monetäre hochschulstatistische Kennzahlen 2014." Fachserie 11 (2016), row 4.3.2.

<sup>5</sup> Hans-Werner Hetmeier, "Methodik der Berechnung der Ausgaben und des Personals der Hochschulen für Forschung und experimentelle Forschung ab dem Berichtsjahr 1995." *Wirtschaft und Statistik* (1998), Heft 2.

<sup>6</sup> [http://www.bbsr.bund.de/BBSR/DE/Raumbeobachtung/Raumabgrenzungen/Raumordnungsregionen/raumordnungsregionen\\_node.html](http://www.bbsr.bund.de/BBSR/DE/Raumbeobachtung/Raumabgrenzungen/Raumordnungsregionen/raumordnungsregionen_node.html), retrieved August 11, 2016. After Saxony's 2008 district reform, the number of RORs decreased from 97 to 96. The 2007 district reform in Saxony-Anhalt 2007 and the 2011 district reform in Mecklenburg-Vorpommern led to changes in the individual RORs' boundaries—but only very minor ones.

<sup>7</sup> Surprisingly, information on public or publicly funded institutions is kept secret—but not information on universities.

the R&D intensity clearly exceeds the national average of 1.37 percent (2013) (Table 1).

The top group comprises twelve regions—among them, Stuttgart, Braunschweig, Munich, Darmstadt, Heidelberg, and Ulm—where the local R&D intensity exceeds the national average by a factor of 1.5 (Map 1). However, there are also major research locations—such as Frankfurt am Main, Cologne, Hamburg, and Düsseldorf—where the R&D intensity falls below the national average. This can be explained by the fact that sectoral structures vary from region to region: Hamburg's economy, for example, is dominated by trade and logistics industries, and that of Frankfurt am Main is primarily supported by banking and transport—all sectors that require little R&D, according to the OECD definition.

## Stuttgart and Braunschweig gaining ground, Munich and Berlin falling behind

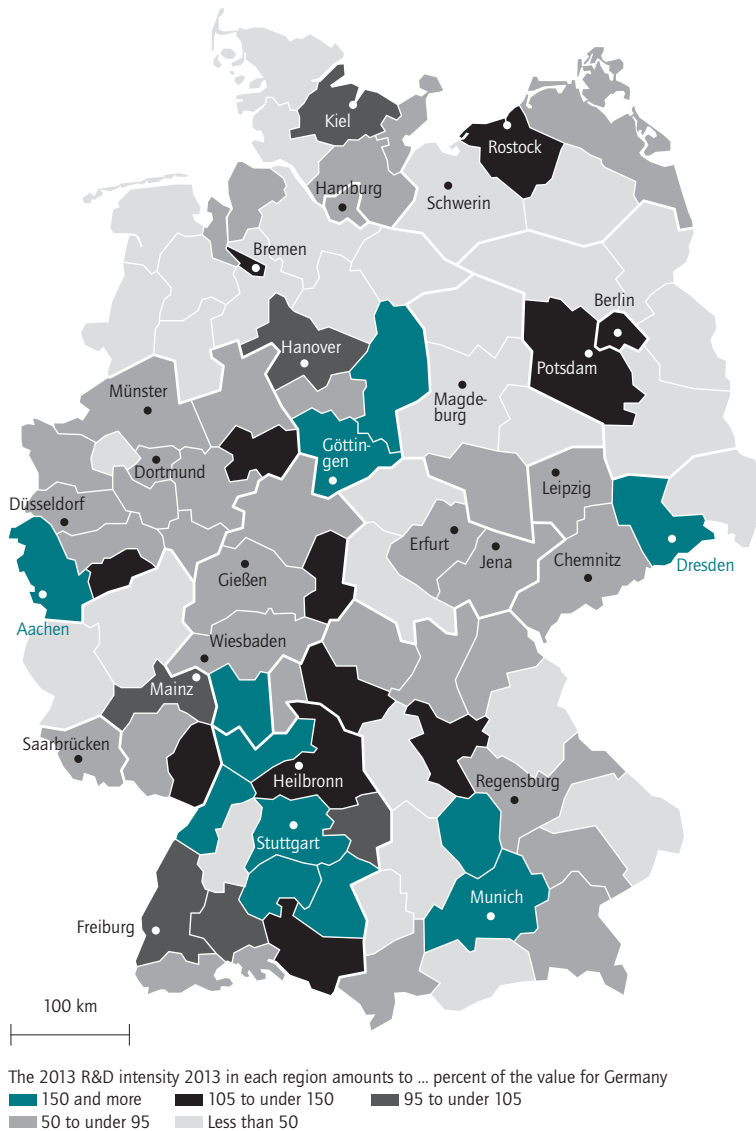
In 2013, nearly 589,000 employees worked in R&D—a figure that is 24.6 percent higher than it was in 2003, with the majority of the increase taking place after 2006.<sup>10</sup> Between 2003 and 2013, the number of R&D personnel in some of the leading regions increased at rates that exceeded the national average; in other leading regions, growth was below average. The most significant growth by far took place in Heilbronn (Franconia), Bielefeld,

<sup>10</sup> In this article, we rely solely on the *R&D personnel* indicator, because the regionalization of R&D expenditure is often based on the regional distribution of R&D personnel—thus a regional analysis of R&D expenditure would not yield significantly more information.

Map 1

**R&D intensity<sup>1</sup> by region<sup>2</sup>**

Index Germany = 100



1 R&amp;D employee share of all employees.

2 ROR according to BBSR.

Sources: German Federal Statistical Office; Stifterverband für die Deutsche Wissenschaft; estimates and calculations by DIW Berlin.

Geometric basis: © GeoBasis-DE/BKG.

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Stuttgart, Braunschweig, Munich, Darmstadt, and Heidelberg have the highest R&D intensities.

Freiburg, Ulm (Donau-Iller in Baden-Württemberg), and Cologne. Below-average growth took place in Düsseldorf, Aachen, and Bonn, while Darmstadt actually saw a decrease in the number of R&D personnel (by eight percent). On the whole, the R&D workforce expanded at a

below-average rate in urban regions (17 percent) and an above-average rate in rural regions (47 percent). These development disparities led to a decline in the share of urban R&D personnel, from 64 percent in 2003 to 62 percent in 2013.

R&D intensity increased over the course of the observation period—from 1.18 percent in 2003 to 1.37 percent in 2013—which means that R&D employment grew more rapidly than did employment in general. Changes in the regions' individual positions can be ascertained by comparing the deviations of local R&D intensity from the national average.

Through this comparison, we can see which regions moved up or down in the rankings relative to the national average. Stuttgart and Braunschweig were already leading regions in 2003 when their R&D intensity amounted to 2.4 times the national average; by 2013, that figure increased to 2.5. The situation is similar for Dresden, Heilbronn, and Ulm, among others (Figure 1). In contrast, Munich and Berlin saw their leads decrease, as did Darmstadt, Aachen, and Karlsruhe. Regions that reduced their lag behind the average include Frankfurt, Cologne, Freiburg, and Bielefeld, while the lagging regions of Düsseldorf and Hannover fell even further back.

Overall, urban areas lost some of their edge despite an increase in R&D intensity from 1.57 percent in 2003 to 1.7 percent in 2013. Growth in rural regions' R&D intensity was even stronger, increasing from 0.57 in 2003 to 0.78 percent in 2013. Though East Germany was able to reduce its lag somewhat, it is important to note that this took place primarily among the East German *Flächenländer*—especially Saxony and Brandenburg—and not in Berlin, where R&D development was comparatively weak.

### Research facility and IHE R&D growing more rapidly than private sector R&D

R&D growth has been driven primarily by the activities of research facilities and IHE. Research facility R&D personnel expanded by 33 percent—up to 98,200 employees—between 2003 and 2013, while IHE expanded their R&D personnel by 29 percent—up to 130,000 employees. These figures represent a significantly larger increase than that of the private sector's R&D workforce, a growth rate that amounted to 21 percent (Figure 2). The strong growth in the public sector is partially due to expenditure related to major government initiatives such as the German Universities Excellence Initiative (since 2005), the Pact for Research and Innovation (since 2006), and the University Pact (since 2007). At the same time, the private sector still accounted for the largest share of R&D by far, with 62.4 percent in 2013 and 64.2 percent in 2003.

## RESEARCH AND DEVELOPMENT

Table 1

### R&D personnel by region, 2003–2013

	2005, 2003 = 100	2009, 2003 = 100	2013, 2003 = 100	2003, structure	2013, structure	R&D intensity <sup>2</sup> 2003	R&D intensity <sup>2</sup> 2013	R&D intensity <sup>2</sup> 2013, Germany = 100	R&D intensity <sup>2</sup> Germany = 100, 2013–2003
Total	101	113	124	100.0	100.0	1.18	1.37	100	0
The 20 leading regions <sup>1</sup>									
Munich	109	110	115	10.6	9.8	3.21	3.25	238	–33
Stuttgart	104	106	126	9.0	9.2	2.86	3.43	251	9
Berlin	95	103	112	5.9	5.3	1.78	1.73	127	–24
Braunschweig	96	105	125	3.3	3.4	2.89	3.37	247	3
Heidelberg	102	112	121	3.4	3.3	2.65	2.97	218	–6
Frankfurt am Main	106	116	124	3.2	3.2	0.97	1.13	83	1
Cologne	94	111	135	2.5	2.7	1.03	1.26	92	5
Darmstadt	90	108	92	3.6	2.6	3.55	3.08	226	–74
Erlangen/Nuremberg	92	108	119	2.7	2.6	1.81	1.96	143	–10
Hamburg	99	116	130	2.4	2.5	1.07	1.22	90	–1
Düsseldorf	109	113	106	2.9	2.4	0.86	0.87	64	–9
Aachen	97	107	106	2.6	2.3	2.26	2.23	164	–27
Dresden	105	118	125	2.2	2.2	2.09	2.43	178	2
Karlsruhe	95	105	112	2.4	2.2	2.08	2.14	157	–19
Hanover	95	104	115	1.9	1.7	1.25	1.32	97	–9
Heilbronn	181	231	274	0.7	1.5	0.69	1.67	122	64
Ulm	104	116	138	1.2	1.4	2.13	2.64	193	13
Freiburg	86	124	140	1.2	1.3	1.06	1.34	98	8
Bielefeld	112	142	158	1.1	1.3	0.63	0.92	68	15
Bonn	93	105	107	1.5	1.3	1.68	1.65	121	–21
Urban regions	100	109	117	63.8	61.7	1.57	1.70	133	–8
Urbanizing regions	99	117	134	25.0	26.3	0.98	1.22	83	7
Rural regions	108	130	147	11.1	12.0	0.57	0.78	48	9
West Germany	101	113	124	84.7	84.2	1.23	1.41	103	–1
East Germany	98	113	125	15.3	15.8	1.00	1.19	85	2
Schleswig-Holstein	103	119	142	1.6	1.8	0.59	0.79	50	8
Hamburg	99	116	130	2.4	2.5	1.07	1.22	91	–1
Lower Saxony	96	106	127	8.1	8.2	1.08	1.25	91	0
Bremen	87	95	111	1.0	1.1	1.13	1.18	96	–9
North Rhine-Westphalia	100	114	123	16.1	15.8	0.88	1.01	75	0
Hesse	99	118	118	8.9	8.0	1.27	1.41	107	–4
Rhineland-Palatinate	93	113	124	3.3	3.3	0.86	0.99	73	–1
Baden-Württemberg	105	115	132	23.1	23.5	1.87	2.28	158	9
Bavaria	103	110	117	19.5	19.3	1.49	1.58	126	–11
Saarland	99	121	154	0.7	0.7	0.54	0.82	46	14
Berlin	95	103	112	5.2	5.3	1.78	1.73	150	–24
Brandenburg	102	121	152	1.3	1.6	0.58	0.84	49	12
Mecklenburg- Western Pomerania	100	123	136	0.9	1.0	0.58	0.78	49	8
Saxony	99	121	133	4.7	4.6	1.04	1.33	88	10
Saxony-Anhalt	99	118	130	1.3	1.3	0.59	0.77	50	6
Thuringia	104	114	121	1.9	1.9	0.89	1.05	75	1

<sup>1</sup> Regions with highest number of R&D personnel in descending order, 2013.

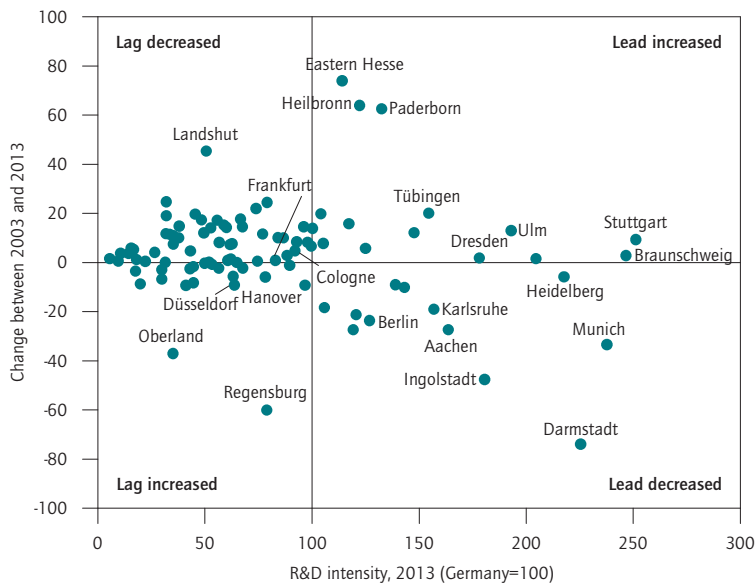
<sup>2</sup> R&D employee share of all employees.

Sources: German Federal Statistical Office; Stifterverband für die Deutsche Wissenschaft; estimates and calculations by DIW Berlin.



Figure 1

### Relative position of R&D intensity<sup>1</sup> 2013 in the regions and their change vs 2003



<sup>1</sup> R&D employee share of all employees.

Sources: German Federal Statistical Office; Stifterverband für die Deutsche Wissenschaft; estimates and calculations by DIW Berlin.

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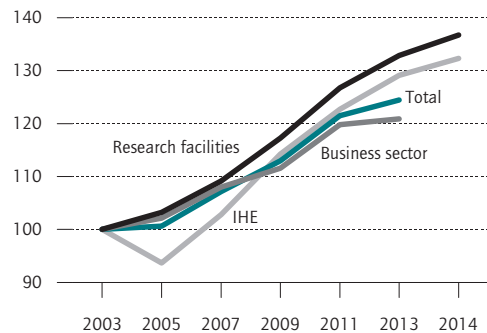
Top regions Munich and Darmstadt have lost some of their lead.

This growth pattern can be found in many of the leading regions; However, in others, the trend was roughly the same in all three sectors while in Stuttgart, Heilbronn, and Freiburg, as well as in rural areas private R&D grew above average

Munich and Berlin are the strongest regions when it comes to research facility R&D (combined, they make up 22.2 percent of Germany's R&D workforce) and IHE R&D (14.3 percent combined) (Table 2). In the private sector, the two strongest regions are Stuttgart and Munich, which together account for 26.1 percent of the total. If one compares the regions with the next-highest rankings, it becomes clear that the R&D activities of research facilities and IHE are not always based near private R&D. These spatial distribution differences are also evidenced by the fact that research facility R&D, with 69 percent, is concentrated more heavily in urban areas than are private R&D (60.3 percent) or IHE R&D (59.8 percent). Differences between East and West are also large: research facility and IHE R&D are strongly represented in East Germany—with 30.0 and 22.4 percent of Germany's R&D personnel, respectively—but its private R&D, at only 9.6 percent, is very weak.

Figure 2

### R&D personnel by sector, 2003–2014, 2003 = 100



Sources: German Federal Statistical Office; Stifterverband für die Deutsche Wissenschaft; estimations and calculations by DIW Berlin.

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Research facilities and IHE are expanding faster than private businesses are.

For R&D conducted in research facilities and IHE, the 2013 spatial distribution barely differs from that of 2003; there were changes in private R&D, however, where the research conducted in urban areas fell sharply.<sup>11</sup> Accordingly, the Gini coefficient<sup>12</sup> for research facility R&D remained fairly stable between 2013 and 2014, while it increased slightly for IHE R&D (Figure 3). The Gini coefficient for private R&D, on the other hand, dropped significantly.

The major difference in the level of concentration between research facility R&D (0.73) and IHE R&D (0.61) is striking. IHE R&D's lower concentration is likely due to the fact that after reunification, the East German federal states actively promoted their regions through the establishment of IHE.

### Göttingen, Dresden, and Aachen lead in public R&D

When it comes to research facility R&D, the region with the highest concentration is Aachen, where the R&D intensity is four times the national average of 0.23 percent—and this lead was even greater in 2003 (Table 2). Other top regions—where the R&D intensity amounts to three times the national average—include Karlsruhe, Dresden,

<sup>11</sup> This has been observable—at least for R&D in the manufacturing sector—since 1998. See Eickelpasch (2008).

<sup>12</sup> The Gini coefficient, a measure of inequality, can help illustrate the degree of R&D's spacial concentration with values between 0 (even distribution across all regions) and 1 (total concentration in one region).



Table 2

**R&D personnel at research facilities and IHE, 2003–2013**

	Research facilities 2013, 2003 = 100	IHE 2013, 2003 = 100	Research facilities 2013, structure	IHE 2013, structure	R&D intensity <sup>2</sup> of research facilities 2013	R&D intensity <sup>2</sup> of research facilities, Germany = 100, 2013	R&D intensity <sup>2</sup> of research facilities, Germany = 100, 2013–2003	R&D intensity <sup>2</sup> of IHE 2013	R&D intensity <sup>2</sup> of IHE, Germany = 100, 2013	R&D intensity <sup>2</sup> of IHE, Germany = 100, 2013–2003
Total	133	129	100.0	100.0	0.2	100	0.0	0.3	100	0.0
The 20 leading regions <sup>1</sup>										
Munich	132	165	10.8	7.6	0.6	263	–17.4	0.5	184	32.2
Stuttgart	140	116	3.2	3.0	0.2	87	6.4	0.2	83	–7.0
Berlin	132	121	11.5	6.8	0.6	274	–20.2	0.5	162	–21.6
Braunschweig	133	133	3.7	1.7	0.6	272	1.3	0.4	124	3.8
Heidelberg	126	146	3.6	3.4	0.5	237	–11.9	0.6	226	25.9
Frankfurt am Main	123	139	2.2	1.9	0.1	55	–3.8	0.1	50	4.2
Cologne	203	129	3.1	2.7	0.2	105	34.5	0.3	94	–2.6
Darmstadt	183	192	1.8	1.7	0.4	154	44.3	0.4	150	50.9
Erlangen/Nuremberg	242	142	1.5	2.9	0.2	82	36.2	0.4	157	11.9
Hamburg	139	140	3.3	3.2	0.3	118	–1.1	0.3	114	3.2
Düsseldorf	94	116	0.7	2.0	0.0	19	–7.2	0.1	52	–4.2
Aachen	117	97	5.7	2.8	1.0	415	–56.6	0.6	203	–66.0
Dresden	148	124	4.4	3.3	0.8	352	38.3	0.7	261	–7.9
Karlsruhe	103	139	5.2	2.3	0.9	375	–112.6	0.5	169	9.9
Hanover	97	126	1.1	3.2	0.1	62	–24.2	0.5	176	–6.3
Heilbronn	66	180	0.3	0.1	0.0	21	–23.6	0.0	5	1.1
Ulm	214	143	0.2	1.4	0.1	25	8.8	0.5	191	12.0
Freiburg	165	120	2.2	2.4	0.4	162	27.4	0.5	174	–19.6
Bielefeld	106	138	0.1	1.0	0.0	7	–1.9	0.1	50	3.5
Bonn	102	118	3.7	2.1	0.8	339	–110.0	0.5	193	–20.6
Urban regions	131	130	69.0	59.8	0.3	139	–3.3	0.3	121	0.5
Urbanizing regions	141	126	21.1	28.8	0.2	71	4.1	0.3	98	–2.1
Rural regions	133	130	9.9	11.3	0.1	47	0.7	0.2	54	0.9
West Germany	132	128	69.7	77.6	0.2	85	–1.0	0.3	95	–0.9
East Germany	135	131	30.3	22.4	0.4	168	6.2	0.3	124	4.7
Schleswig-Holstein	127	118	2.7	2.2	0.2	86	–2.8	0.2	70	–5.7
Hamburg	139	140	3.3	3.2	0.3	118	–1.1	0.3	114	3.2
Lower Saxony	122	130	8.1	8.7	0.2	91	–10.1	0.3	98	–1.3
Bremen	174	102	2.2	1.5	0.4	178	43.8	0.3	122	–30.3
North Rhine-Westphalia	125	115	16.7	19.4	0.2	78	–4.4	0.3	91	–9.9
Hesse	143	128	4.4	6.5	0.1	56	4.6	0.2	84	0.5
Rhineland-Palatinate	155	136	2.0	3.5	0.1	42	5.9	0.2	75	3.6
Baden-Württemberg	124	131	15.4	15.8	0.3	110	–7.9	0.3	112	1.1
Bavaria	143	149	13.7	15.6	0.2	82	3.9	0.3	93	10.0
Saarland	176	116	1.1	1.2	0.2	91	26.2	0.3	94	–4.7
Berlin	132	121	11.5	6.8	0.6	274	–20.2	0.5	162	–21.6
Brandenburg	132	148	4.0	1.7	0.4	158	3.2	0.2	67	9.9
Mecklenburg- Western Pomerania	135	122	2.2	1.8	0.3	125	10.6	0.3	103	1.6
Saxony	147	149	7.5	7.3	0.4	158	19.7	0.4	153	25.1
Saxony-Anhalt	130	111	2.6	2.2	0.3	108	5.3	0.3	90	–7.5
Thuringia	130	134	2.5	2.7	0.2	103	1.8	0.3	110	8.1

1 Regions with highest number of R&D personnel in descending order, 2013.

2 R&D employee share of all employees.

Sources: German Federal Statistical Office; Stifterverband für die Deutsche Wissenschaft; estimations and calculations by DIW Berlin.

Figure 3

### Regional concentration of R&D personnel, 2003–2013, Gini coefficients



Sources: German Federal Statistical Office; Stifterverband für die Deutsche Wissenschaft; estimations and calculations by DIW Berlin.

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Regional concentration is declining in business enterprises R&D.

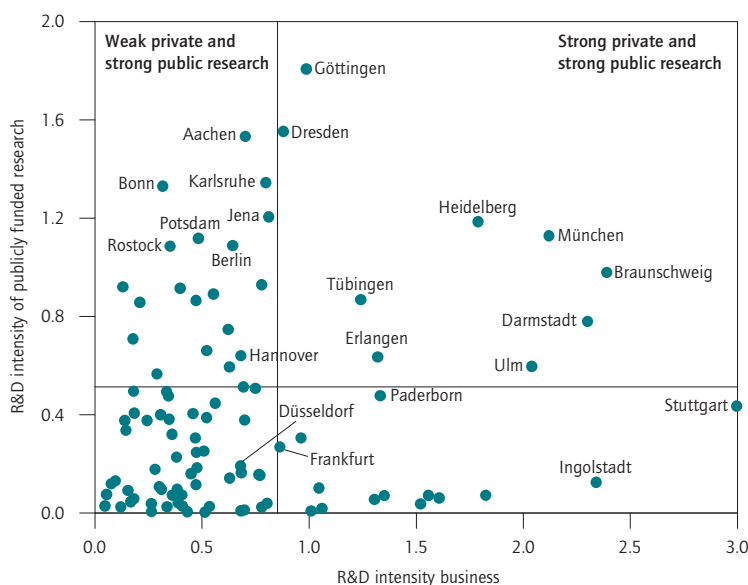
and Bonn, as well as smaller areas such as Göttingen and Havelland-Fläming (with Potsdam). With the exception of Dresden, their leads have been decreasing since 2003.

Research facility R&D intensity is well above the national average in urban areas (139 percent), and well below in urbanizing and rural areas (71 percent and 47 percent, respectively). With the exception of Berlin, the East German federal states managed to expand their leads. Among the West German states, the biggest changes include Bremen's gain and the losses of Baden-Württemberg and Lower Saxony, respectively.

For IHE R&D intensity, the regional spread is not as pronounced as it is for research facilities. Göttingen, the only region with three times the national average, is the leader here (Table 2). The next-highest ranked regions—Würzburg, Dresden, Tübingen, Heidelberg, Jena, Kiel, and Aachen—have double the national average. Three of these eight top regions expanded their leads, while the other five lost some of theirs. As in the case of research facility R&D, most of the East German states—especially Saxony—were able to expand their leads in IHE R&D intensity; only Berlin and Saxony-Anhalt lagged behind. In West Germany, Bavaria saw the biggest increase, while Bremen saw the biggest decrease.

Figure 4

### R&D intensity<sup>1</sup> of business and publicly funded research (research facilities and IHE), 2013



<sup>1</sup> R&D employee share of all employees.

Sources: German Federal Statistical Office; Stifterverband für die Deutsche Wissenschaft; estimations and calculations by DIW Berlin.

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Locations with strong public and weak private R&D are Aachen, Bonn, Karlsruhe, Potsdam, Jena and Berlin.

If research facilities and institutions of higher education are combined into one category—"public research"—then there are 20 regions with R&D intensity that amounts to 1.5 times the national average (Map 2). The frontrunners here are Göttingen, Dresden, and Aachen, with triple the national average, though Aachen and Göttingen were losing some of their edge while Dresden was gaining. Dresden's lead has given a boost to greater Saxony and East Germany on the whole, which have been gaining ground over other areas.

### Private R&D's spatial relationship with research facility R&D stronger than with IHE R&D alone

Does the spatial relationship between the locations of private and public research activities indicate that private R&D can be stimulated by a proximity to public R&D?

The R&D intensity in both the public and private sectors is particularly high in Munich, Braunschweig, Heidelberg, Göttingen, Ulm, and Darmstadt (Figure 4). Bonn, Aachen, Dresden, Karlsruhe, Berlin, Bremen, and Freiburg have a high level of public but little private research activity, while the configuration is reversed for Stuttgart, Ingolstadt, and Heilbronn.

Overall, urban areas have a higher concentration of both public and private research than do less densely popu-

lated regions. West Germany falls below the national public R&D average but exceeds the national average for private R&D—primarily due to the high rankings of Baden-Württemberg and Bavaria. In East Germany, this configuration is reversed.<sup>13</sup>

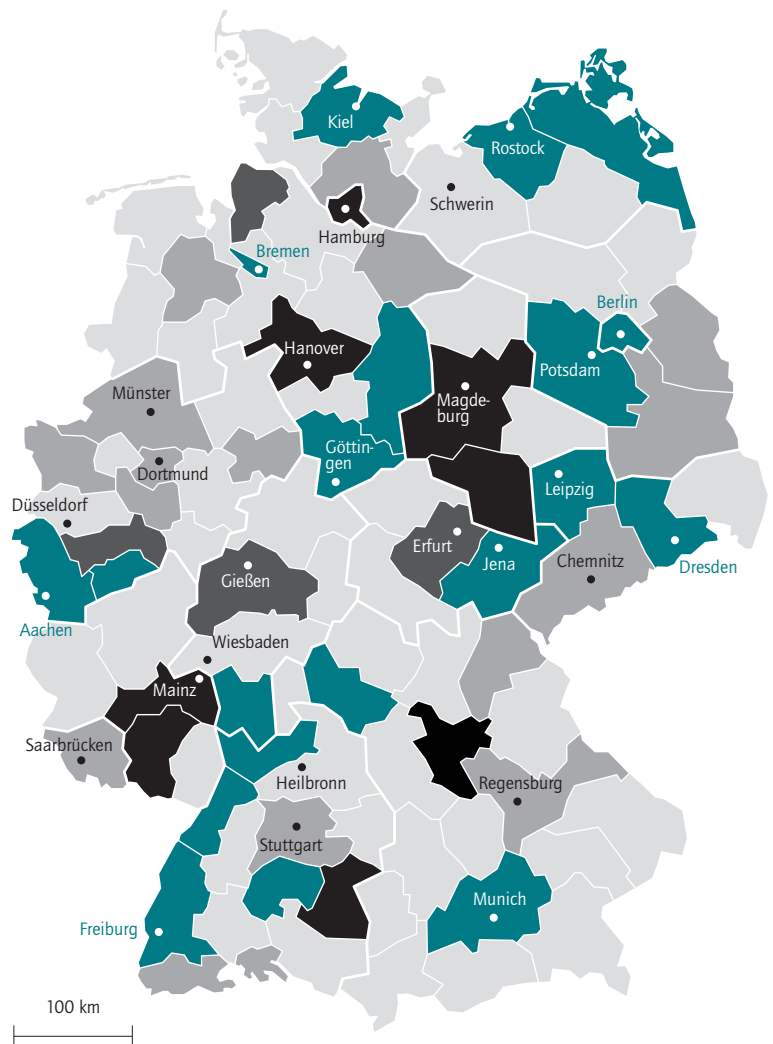
Further clues indicate correlations that show the strength of the relationship between a specific region's public and private R&D. For 2013, the correlation coefficient between the R&D of manufacturing and research facilities amounts to 0.57; between the private sector and universities, to 0.63; and between the private sector and IHE third-party funding, likewise to 0.63 (Table 3).<sup>14</sup> The correlation coefficients are similar for the preceding years; no particular trend in development is evident.

Whether being close to public R&D has any significance for private R&D also depends on the region's absorptive capacity. A low level of industry suggests low absorptive capacities. Furthermore, because R&D is a strategic factor for businesses, it is often found at the same location as the company's top management or in close proximity to industrial production. Though this is clearly the case for single-location businesses conducting research, it also applies to many large companies with several production sites.<sup>15</sup> We can thus expect spatial proximity to the manufacturing sector to play a role in the spatial distribution of private R&D. In fact, the correlation between corporate R&D and manufacturing capacities (.74 in 2013) is higher than both the correlation between corporate and research facility R&D (0.56) as well as business and IHE R&D (0.63).<sup>16</sup>

To rule out possible interdependencies between the individual factors, we performed multiple regressions. The dependent variable here is corporate R&D personnel, and the independent variables are the R&D personnel of research facilities and universities (basic and third-party funds) as well as employees working in the manufacturing sector.<sup>17</sup> The results indicate that private R&D is significantly correlated with research facility R&D as well as the presence of local industrial capacities (Table 4). The other factors play a non-significant role. The results

Map 2

### R&D intensity<sup>1</sup> for research facilities and IHE 2013 by region<sup>2</sup> Index Germany = 100



The 2013 R&D intensity 2013 in each region amounts to ... percent of the value for Germany

150 and more	105 to under 150	95 to under 105
50 to under 95	Less than 50	

1 R&D employee share of all employees.

2 Boundaries according to BBSR.

Sources: German Federal Statistical Office; Stifterverband für die Deutsche Wissenschaft; estimates and calculations by DIW Berlin.

Geometric basis: © GeoBasis-DE/BKG.

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In publicly funded research East Germany is above average in private R&D below average.

support the assumption that although spatial proximity to public research is of some importance, proximity to industry is more important for private research.

These calculations indicate neither causality nor direction of action. What also must be taken into account is the fact

<sup>13</sup> Alexander Eickelpasch, "Forschung, Entwicklung und Innovationen in Ostdeutschland: Rückstand strukturell bedingt." *DIW Wochenbericht* no. 41 (2015), pp. 907-18.

<sup>14</sup> The correlation between IHE R&D and research facility R&D, however, is much stronger—which is unsurprising, given that research facilities tend to exist or be established near universities.

<sup>15</sup> According to data collected by the SV, the number of all research centers including those which are separated from their corporate headquarters is five percent higher than the number of research-based companies.

<sup>16</sup> The affinity of private R&D to manufacturing sector also indicates that the correlation of private R&D with the number of persons employed in the whole economy is significantly lower than the correlation with employment in the manufacturing sector.

<sup>17</sup> In order to avoid double counting, without private R&D personnel.

Table 3

**Relationship between business R&D, R&D in research facilities, IHE, and manufacturing, 2003–2013. Correlation coefficients**

	Research facilities	IHE, total	IHE, basic funds	IHE, third-party funds <sup>1</sup>	Manufacturing <sup>1</sup>
2013	0.568	0.627	0.5754	0.6327	0.7439
2011	0.5809	0.6124	0.5842	0.6128	0.7358
2009	0.5928	0.6268	0.6086	0.6275	0.7348
2007	0.571	0.6074	0.582	0.6158	0.754
2005	0.6181	0.6,039	X	X	0.7238
2003	0.5912	0.608	X	X	0.7235

<sup>1</sup> Employed persons without business R&D personnel.

Sources: German Federal Statistical Office; Stifterverband für die Deutsche Wissenschaft; estimations and calculations by DIW Berlin.

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Spatial relationship of private R&D with manufacturing industry is stronger than with public research.

that not all IHE R&D—in this case, basic research in particular—and research facility R&D are needed by or have a direct impact on the regional economy. There may also be a lack of knowledge transfer within the region, or an unwillingness of companies to collaborate with public institutions. Only a detailed regional analysis can reveal which individual factors are playing a role here.

## Conclusion

Innovation potential at the regional level remains concentrated in a few major urban areas, though rural areas overall have been able to gain ground despite lagging behind the national average. A high concentration of public R&D helps attract private R&D to a given region, thus stimulating the development of a competitive local economy. The growth of R&D in research facilities and universities has been especially dynamic. Research facility R&D is more highly concentrated in urban regions than is private sector R&D, while IHE research is less concentrated. Some of the key locations for public R&D (research facility R&D and IHE R&D) also have high levels of private R&D: these include Munich, Braunschweig, Heidelberg, Göttingen, Ulm, and Darmstadt. Other major regions for public R&D have low levels of private R&D: these include Bonn, Aachen, Dresden, Karlsruhe, Berlin, Bremen, and

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Table 4

**Significance of R&D for research facilities, IHE, and manufacturing for business R&D in regions; regression analyses**

Variable	2007 to 2013	2003 to 2013
Research facilities <sup>1</sup>	1.520*** (0.352)	1.804*** (0.337)
IHE, basic funds <sup>1</sup>	−1.852 (1.235)	−
IHE, third-party funds <sup>1</sup>	0.803 (0.955)	−
Universities <sup>1</sup>	−	−0.567* (0.314)
Manufacturing <sup>2</sup>	0.0745*** (0.0116)	0.0710*** (0.00899)
East Germany	−603.9 (438.7)	−457.6 (357.3)
Constant	−2.775*** (711.5)	−2.941*** (641.4)
Observations	384	576
R <sup>2</sup>	0.682	0.676

Robust standard error in parentheses.

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

<sup>1</sup> R&D personnel.

<sup>2</sup> Employed persons without business R&D personnel.

Without showing the annual dummies.

Source: German Federal Statistical Office; Stifterverband für die Deutsche Wissenschaft; estimates and calculations by DIW Berlin.

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Industry and research facilities are significant.

Freiburg, Stuttgart, Ingolstadt, and Heilbronn have very high levels of private R&D but low levels of research facility and IHE R&D. Overall, the study shows that there is indeed a spatial relationship between private and public R&D, but it is weaker than the relationship between private R&D and regional manufacturing industry.

The results suggest that region-oriented innovation policy should go beyond promoting knowledge transfer within the region: it also seems necessary to support the regional economy in exploiting extra-regional knowledge potential and to take more closely into account local industry as a customer of local public R & D—not least within the framework of local settlement policy.



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#### FIVE QUESTIONS FOR ALEXANDER EICKELPASCH

## »Policy needs to strengthen transregional networking of private and public research«

1. How large is Germany's research and development (R&D) workforce, and which regions have the highest concentration of R&D activity? In 2013, the German R&D workforce amounted to 589,000 people. We find a strong concentration in the two regions (so-called *Raumordnungsregionen*) of Stuttgart and Munich, with 19 percent of the workforce based there. Germany's most densely populated regions are home to 62 percent of all R&D personnel, which means we have a strong spatial concentration in urban areas overall.
2. Where has R&D increased over the past few years, and where has it decreased? To answer such a question, we typically compare the number of researchers with the number of total employees in a given area—this is the idea behind the concept of "R&D intensity." Taking this into account, most regions with a large number of R&D personnel also have a high level of R&D intensity. This is the case not only in R&D-heavy Stuttgart and Munich, but also in Braunschweig. Overall, the German R&D workforce increased by 25 percent between 2003 and 2013, with the most significant growth taking place in Heilbronn, Bielefeld, Freiburg, Ulm, and Cologne. Düsseldorf, Aachen, and Bonn experienced below-average growth, and Darmstadt actually saw a decrease in the number of R&D employees. When it comes to R&D intensity, however, the results are a bit different: among the large regions, the winners here are Cologne, Dresden, Heilbronn, and Ulm. Munich and Berlin—two of the top regions—saw a drop in R&D intensity, as did Darmstadt, Aachen, and Karlsruhe.
3. What kinds of organizations lead when it comes to R&D: research institutes, universities, or businesses in the private sector? The private sector accounts for 61 percent of all R&D personnel. The remaining 39 percent work in universities and research facilities—and most of these, including the Fraunhofer Society and the Helmholtz Association, are publicly funded. From 2005 onward, R&D staff in universities and research institutes experienced a sharp increase of at least 30 percent, while R&D staff in the private sector grew by only 20 percent. This development is primarily due to the fact that in 2005, the Federal Government began implementing major academic initiatives such as the Pact for Research and Innovation, the German Universities Excellence Initiative, and the University Pact.
4. Are public and private R&D activities concentrated in different areas? If so, to what extent? R&D in public research facilities is usually more concentrated in densely populated areas than is R&D in universities or the private sector: 22 percent of R&D personnel working in public research facilities are based in Berlin and Munich, for example. Munich and Berlin also account for 14 percent of the R&D in universities, while 23 percent of R&D personnel in the private sector are concentrated in other regions, such as Stuttgart. So it's not always the case that private research is being conducted in areas where public research is taking place.
5. Since spatial proximity creates synergy effects, do the differences in distribution hinder innovation potential? That is an important issue. Policy aims to link research results from public research more closely with local companies and corporate research activities—this typically falls under the concept of regional innovation or cluster policy. We have found that an area with a high concentration of public research does not necessarily have a high concentration of private research as well. In our opinion, policy should respond directly to this fact, and not just promote the link between regional actors. It should also consider the extent to which it is useful to promote the transregional networking of research facilities, universities, and local businesses or to strengthen the local economy related to R&D.

Interview by Erich Wittenberg



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