R&D in Germany and Turkey – a Comparison

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1.1 Introduction

> Innovative solutions are the factors that drive our prosperity and support our quality of life. They strengthen Germany's position as a leading industrial and exporting nation. And they make it possible to find creative answers to the urgent challenges of our time (Bundesministerium für Bildung und Forschung 2014a, p. 3).

These are the words the federal government used in 2014 to substantiate its continued commitment to research and development in accordance with the "High-tech Strategy". This insight, however, is far from new. In 2000, at the European Council meeting in Lisbon the Heads of State and Government had set the objective to make the European Union "the most competitive and dynamic knowledge-based economy in the world", the main in-

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strument for this endeavor being a Europe-wide increase of intramural R&D expenditures to 3% of the gross domestic product by 2010. Like Germany, R&D activities are here considered "a driving force for a competitive and dynamic knowledge-based economy" (Commission of the European Communities 2002, p. 3).

Consequently, the promotion of R&D is not only an integral part of various government programs, but also of importance for supranational organizations like the United Nations or the OECD.

In consequence, given the economical and societal magnitude of the topic, it would be appropriate to dedicate attention to comparative observations of R&D activities in the focus countries Germany and Turkey within the framework of the *Second Wirtschaftswissenschaftliches Forum*. This could involve assessing the current state and carrying out an international comparison. Recommendations for political and economic actions should be discussed only as an afterthought.

The international R&D survey (briefly described in the following chapter) serves as empirical basis of the analysis.

The rest of the paper is structured as follows:

- Sect. 1.2: The R&D survey on the basis of international agreements set forth in the Frascati manual
- Sect. 1.3: General economic reflections on Germany and Turkey
- Sect. 1.4: R&D systems in Germany and Turkey
- Conclusion

1.2 The International R&D Survey

The member states of the European Union (pursuant to Regulation (EU) 995/2012), OECD countries, and other countries gather data on research and development (R&D). The common framework of the Frascati manual, prepared and published by the OECD (2015), allows for an international comparison of the R&D structures in the individual countries.

The R&D survey distinguishes between four R&D sectors: business enterprises, higher education, government and PNP.[1] Data on the different sectors is gathered and published separately. There are, however, cross-sectorial analyses providing an overall societal or economical view on R&D structures (cf. also Bundesministerium für Bildung und Forschung 2014b; European Commission 2013; Wissenschaftsstatistik 2015a, 2015b).

The core indicators of the R&D survey are intramural R&D expenditures and R&D personnel. Intramural R&D expenditures are defined as expenditures for research and developmental activity performed in-house. Research contracts awarded to external institutions are consequently considered extramural R&D. In addition to scientific staff, R&D

[1] Private Non Profit.

personnel also comprises technicians and so-called "other supporting R&D staff" (these being mostly administration employees, however, attributable to R&D activities).

Key structural aspects to be examined in the R&D survey include

- R&D-performance (Where is R&D carried out?) versus R&D-funding (Who is financing R&D?). Industrial R&D (R&D in the business enterprise sector), for instance, can be state-funded.
- Regional R&D distribution at the Federate State level (NUTS[2] 1) is of particular interest in a federal country like Germany. However, also underlying regional structures (NUTS 2 or NUTS 3) as well as special aggregations (chamber's districts, metropolitan regions etc.) can be covered.
- When assessing R&D personnel, gender issues are crucial.

The findings are published by Eurostat (including Turkey), OECD, BMBF and Stifterverband/Wissenschaftsstatistik.

1.3 Germany and Turkey – a Brief Economic Overview

Some particular economic and societal issues, such as research and development, must be examined in a broader context in order to allow practical interpretations. For that reason, this chapter offers a brief comparison of important facts on Germany and Turkey.

1. **National territory**
   Turkey is twice the size of Germany (783,562 km^2 compared to 357,340 km^2).[3]
2. **Population**
   In 2014 the number of inhabitants where roughly the same for Turkey and Germany (Turkey: 78.6 million, Germany: 80.8 million).[4] This means that Germany's population density is on average twice as high as Turkeys (226 and 98 inhabitants per square kilometer, respectively). This number is somewhat misleading, however, as the regional distribution in Turkey is considerably more heterogeneous than in Germany. For example, more than 15 million people (almost one fifth of the population) live in the greater Istanbul area (as defined in NUTS 2). Germany's largest agglomeration, the Ruhr district (as defined by the Regionalverband Ruhr[5]) has a population of only 5 million – slightly over 6%.
   With reference to the urban/rural distribution, however, the two countries are fairly similar. 57% of the German population and 52.5% of the Turkish population live in an urban environment.

[2] NUTS = Nomenclature des unités territoriales statistiques is the official regional classification of the EU. For Germany NUTS 1 corresponds to the federal states, NUTS 2 to the administrative districts and comparable aggregations, and NUTS 3 to the counties and county boroughs.
[3] Source: www.wikipedia.de (08.01.2016).
[4] Source: Eurostat.
[5] The Ruhr district is no administrative unit. Therefore there is no official delimitation.

3. **Gross domestic product (GDP)**
   With 3757.1 billion US dollars, the German GDP was two and a half times the amount of the Turkish GDP (1502.5 billion US dollars) in 2014[6], a per capita GDP of 45,619 USD and 19,610 USD for Germany and Turkey, respectively. A breakdown by industries of the economic output reveals that in Germany a quarter of all value is created in the industry (approximately 22% in Turkey). Agriculture contributes 8% to the total value created in Turkey, but only 0.8% in Germany. This results in a number of similarities in the economic performances of both countries which are, as we are going to see, only partially reflected in the R&D sector structure.
4. **Intramural R&D expenditures**
   German intramural R&D expenditures amounted to €79,729.51 million for all sectors in 2013, €53,566.2 million of which was accounted for by the business enterprise sector. In Turkey these numbers are €5844.61 million for overall R&D expenditures and €2775.4 million for R&D in the business enterprise sector.

1.4 R&D Systems in Germany and Turkey

1.4.1 Intramural R&D Expenditures – Absolute and in Relation to the GDP

As already mentioned, with almost €80 billion, intramural R&D expenditures across all sectors in Germany (GERD = Gross Domestic Expenditures on R&D) are more than thirteen times as high as in Turkey. Fig. 1.1[7] shows both countries in an international ranking. In order to better assess this relation one needs to consider the following comparative figures:

1. The most research-oriented federal state in Germany is Baden-Württemberg with €20.2 billion worth of intramural R&D expenditures. In a ranking of German federal states, Turkey would rank 6th Turkish R&D expenditures are comparable to the ones of the administrative district of Darmstadt (with Frankfurt/Main as the largest city).
2. Volkswagen is the most research-oriented enterprise in the world. In 2014 VW spent approximately €13.1 billion on research and development (European Commission 2015). If Turkey was an enterprise, it would rank around 13th in an international business ranking (equivalent to the Daimler AG).

A comparison of absolute R&D data in this form is certainly impractical. Therefore, both in the field of innovation research and in the political debate the relation between intramural R&D expenditures and the gross domestic product has established itself as a comparative figure.

[6] Source: OECD.
[7] All R&D data refers to 2013, with the exception of the US and Switzerland, where only data on 2012 was available.

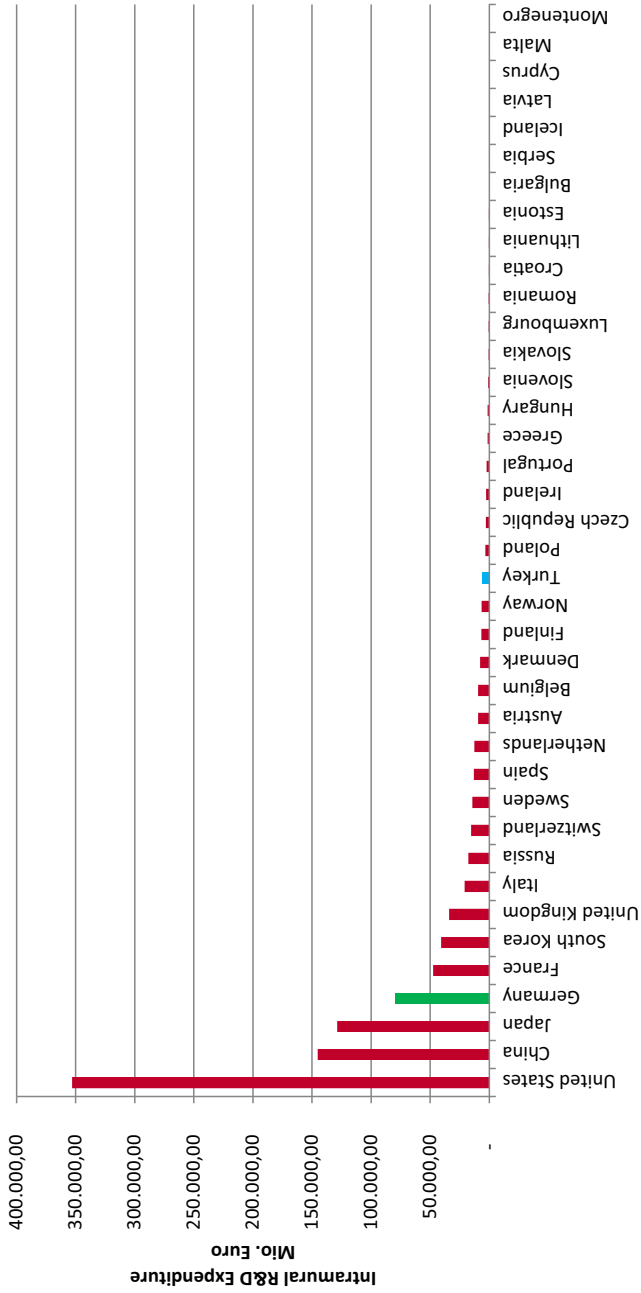

Fig. 1.1 Intramural R&D expenditures 2013

Fig. 1.2 shows the corresponding international ranking.

Measured by this indicator, the most research-oriented countries are South Korea (4.15%) and Japan (3.47%), followed by the Scandinavian countries Finland (3.3%), Sweden (3.3%) and Denmark (3.08%). With 2.83% Germany ranks eighth, just above the US (2.81%). Turkey (0.95%) ends up in the bottom third, however, still higher than several other EU countries. With 2.03% the EU itself (EU 28) falls considerably short of its own 3% aim. Even the EU 15 states achieve only 2.12%.

A look at the development of R&D expenditures in Germany and Turkey over the last 20 years provides further interesting insight. Fig. 1.3 shows the annual rate of change between 1993 and 2013.

Two points appear to be particularly striking:

1. The total increase during the period considered was considerably higher in Turkey than it was in Germany. Whereas the amount of German intramural R&D expenditures merely doubled, the Turkish growth rate was at over 750%, however, with different increases in different sectors. The business enterprise sector saw the most drastic increase, with an almost unbelievable increase of research activities by the factor 16 within 20 years. Well below that are the higher education sector (+800%) and the government sector (+400%). In addition to that, R&D activities appear to vary with the years. In the first decade (1993–2003) R&D expenditures were not even doubled (+90%). The following decade (2003–2013) saw a 350% increase, evidently due to an increased political support of R&D (cf. also European Commission 2013, p. 329).
2. Whereas the changes in Germany remain relatively constant (annual rate of change below 10%) and consistently positive, Turkish R&D expenditures are far more volatile, with a more-than-40% decrease between 1993 and 1994 on the one hand, and a 40% increase between 2005 and 2007 on the other hand. This kind of high volatility is displayed throughout all sectors. The sectors are, however, not positively correlated as one might assume. In 2004, for instance, the government sector experienced a slight decrease, whereas the other sectors saw an increase of about 30% each. In 2008 R&D expenditures in the higher education sector declined significantly, while expenditures in the other two sectors rose substantially.

All in all it can be said that, as also noticed by the EU, with the turn of the millennium R&D increasingly became the focus of Turkish policy. So far, however, R&D could not be put onto a stable, sustainable growth path.

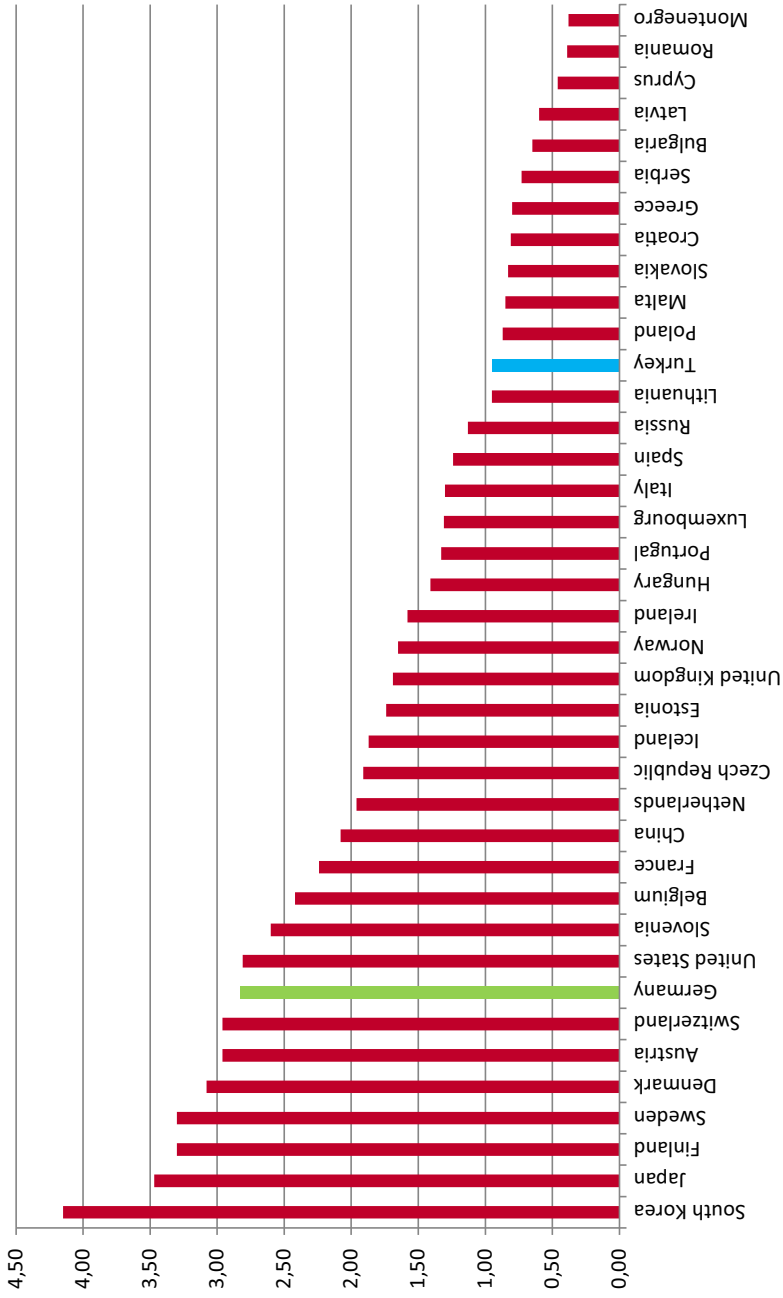

Fig. 1.2 Intramural R&D expenditures in relation to the GDP 2013

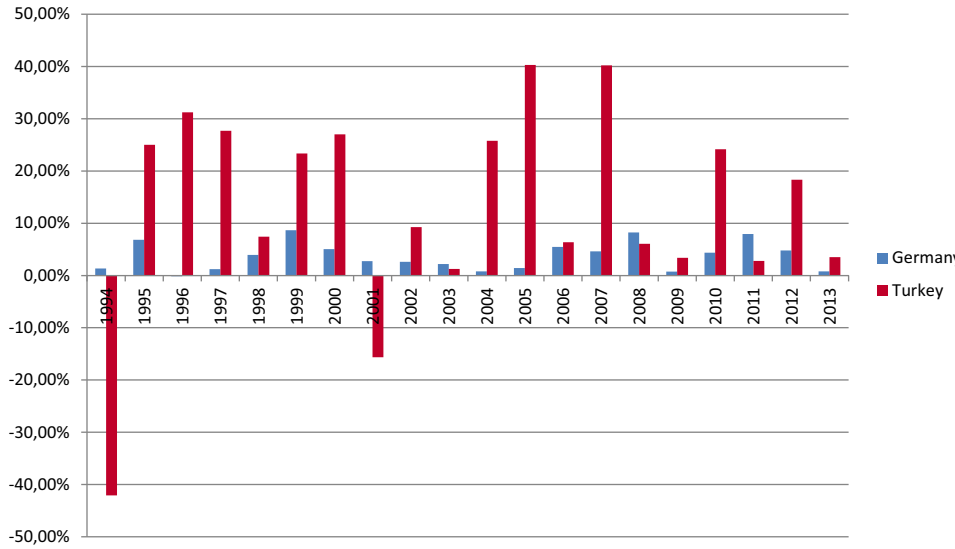

Fig. 1.3 Rates of change of intramural R&D expenditures

1.4.2 The Sectoral Breakdown

When the EU set its 3% target, it did so with the stipulation that two thirds of national R&D expenditures should be spend within the business enterprise sector. This, however, was more of a means to an end than an economic objective. It had been supposed that the business enterprise sector did not invest enough in R&D compared to, for example, the US, which allegedly accounted for the 80% gap between US and European R&D expenditures. Fig. 1.4 shows that in addition to Germany other countries, too, meet the requirements. Turkey was at 47% in 2013, with an apparent investment gap in private R&D efforts. It should be specified, however, that

1. since 1993 the rate of R&D in the business enterprise sector in Turkey has increased from 23 to 47%, meaning that this sector is making a considerably bigger effort today than it was 20 years ago.
2. a simple calculation shows that increased efforts of the private sector alone do not suffice to bring the Turkish R&D expenditures to a level comparable to that of leading research nations. If one was to take the expenditures in the higher education sector and the government sector in the year 2013 as given, private expenditures would have to rise to €9.2 billion (currently €6.136 billion) to meet the 2 : 1 requirements. Based on the assumption of a constant GDP, however, this would account for merely 1.5% of the GDP (currently 0.95%) – only half of the intended 3%. Increased effort is required, therefore, not only in the business enterprise sector.

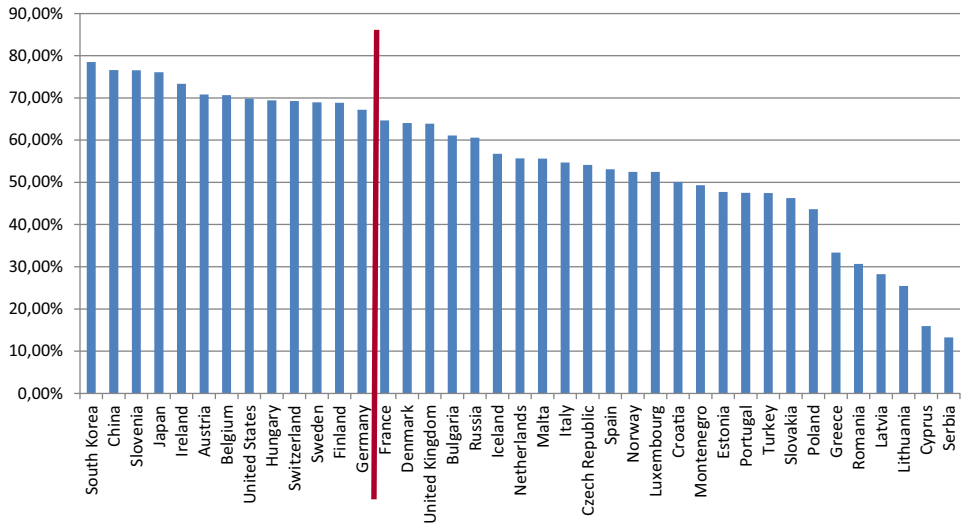

Fig. 1.4 Share of the business enterprise sector in intramural R&D expenditures 2013

1.4.3 Funding

The other question besides R&D performance ("Who is doing it?") is the one of funding ("Who is paying for it?"). It is easy to see that the institution paying for R&D is not necessarily the one conducting it. The State, for instance, may fund R&D projects in enterprises and at universities, and universities may acquire external funding for projects from enterprises.

Unfortunately international R&D surveys do not always cover R&D funding with the appropriate amount of detail. Eurostat, for instance, reports R&D funding just "by the business enterprise sector". Whether this means that an enterprise is funding its own R&D or that it is carrying out research for another enterprise remains unclear. Such information can often only – if anywhere – be found in national publications.[8]

All the same, even the Eurostat publications allow for interesting insight into R&D financing structures. In the following, the focus will be on three issues:

1. To what degree are enterprises involved in the funding?
2. How far is the State involved?
3. What role do other countries play?

In Germany approximately 65% of all domestic R&D expenditures are funded by the business enterprise sector, earning Germany a place among the leading countries Japan, South Korea, and, interestingly, China. Hence, the German business enterprise sector is

[8] For Germany cf. Wissenschaftsstatistik (2015).

more strongly involved in R&D than for example the American one (with share of financing of slightly under 60%). The share of business-based R&D funding in Turkey amounts to approximately 49%, making Turkey rank more or less in the middle, ahead of Norway (43%) and the UK (46%), tied with Austria (49%), and slightly behind the Netherlands (52%).

The degrees of State involvement in Germany and Turkey are, relative to the total sum, more or less similar (27–29% of intramural R&D expenditures), situating both countries in the lower part of the middle range. This category is headed by Russia (67%), followed by several lesser developed countries such as Cyprus, Serbia, Greece, and Romania. But even in countries such as Norway, Spain, and Italy does the state share in funding amount to more than 40%.

Foreign R&D funding in the business enterprise sector is not very common.[9] With slightly above 5% in Germany and a mere 0.8% in Turkey, the overall share of foreign funding is rather low in both countries. However, a look at other countries reveals that this is quite common: Foreign shares in Japan and Korea amount to significantly less than 1%, and 3.8% in the US, which raises the question as to why.

Countries with a low degree of foreign funding can be roughly divided into two groups.

1. Countries focusing more on the export of R&D: Globally operating enterprises tend to conduct their own research globally as well. If these enterprises are, for example, relatively centrally organized, R&D is more likely to be exported from these countries than imported.[10] The US and Germany are typical representatives of this category.
2. Countries with enterprises lacking foreign partners. This appears to be the problem Turkey is facing. Czernich (2014) found that German enterprises tend not to name Turkey as an attractive target country for their R&D activities.

1.4.4 Personnel

588,615 people were involved in R&D in Germany in 2013[11] – approximately 1.5% of the overall workforce. In Turkey 112,969 FTEs were involved in R&D, 0.5% of the overall workforce. Broken down by sectors, 61% of the German R&D personnel were employed in the business enterprise sector and 22% in the higher education sector. In Turkey the numbers were at 52 and 38%, respectively.

[9] On the international interdependence of R&D cf. also Czernich and Kladroba (2013) and Belitz (2015).

[10] On the different forms of organization of foreign R&D cf. Czernich (2014).

[11] R&D personnel is generally measured in form of Full Time Equivalents (FTEs). The data on the proportion of women, however, is presented as headcount, as this value was available for a higher number of countries.

The R&D survey distinguishes three personnel groups: researchers, technicians, and other supporting R&D staff. The proportion of researchers among R&D personnel was around 60% in Germany, with a relatively large range of 55% in the business enterprise sector and 76% in the higher education sector. The Turkish R&D survey presents a detailed listing of personnel groups only for the business enterprise sector. Here, the proportion of researchers amounted to 69% – significantly higher than in Germany.

An evaluation of the data according to gender revealed a proportion of women among the entire R&D personnel of 27% in Germany and 36.2% in Turkey. Considering only scientific personnel, i.e. highly qualified staff with a university degree, the proportion of women would be 28% in Germany, ranking Germany 29th in a ranking of 34 countries for which Eurostat provides R&D personnel data. Turkey ranks 17th and therefore in the middle. Just for comparison – at the top of the ranking are Latvia and Lithuania with a proportion of women of more than 50%. At least 10 of the 34 countries ranked have a percentage of women of over 40%.

It should be noted, however, that neither Germany nor Turkey are homogeneous in themselves. First of all there are considerable differences between individual sectors. In Germany the female share in scientific personnel in the higher education sector is 38%. In the business enterprise sector, it is a mere 14%. In Turkey a similar trend is noticeable, albeit at a higher level, with a 42% proportion of women in the higher education sector and 24% in the business enterprise sector. The phenomenon of a higher percentage of women in the higher education sector than in the business enterprise sector can be observed throughout all industrial nations without exception, however, with varying differences between individual sectors.

Still, both in Germany and Turkey there are also differences within individual sectors, however, with similar results. Within the business enterprise sector, for instance, the proportion of women is comparatively high in the food sector, the textile industry, agriculture and the manufacture of pharmaceuticals. The percentage of women in the manufacture of pharmaceuticals, for instance, is over 40% in Germany and even over 65% in Turkey. Traditional industries such as the manufacture of electrical and optical equipment, the manufacture of machinery, and the manufacture of motor vehicles on the other hand have a low female share in the overall workforce, with less than 10% in Germany and approximately 15% in Turkey.[12]

There is, however, a noticeable difference between Germany and Turkey in regard to the proportion of women in the higher education sector broken down by fields of science. In Germany medicine, agricultural sciences, the humanities and the social sciences have a high percentage of women (over 40%, partly also over 50%). At the bottom end of the ranking are the STEM subjects, with a proportion of women of only 20–30%. A more homogeneous emerges in Turkey. With a good third, the lowest proportion of women can

[12] For a comprehensive representation of R&D personnel within the German business enterprise sector cf. Schneider and Stenke (2016).

be found in agricultural sciences and engineering sciences. The other fields of science feature a percentage of women of more than 40%, again with medicine at the top (48%).[13]

It is also interesting to compare the development over time of the proportion of women among scientific personnel in Germany and Turkey. During the last ten years since 2003 the percentage of women in Turkey has remained largely unchanged. Germany, on the other hand, has seen an increase from below 20 to 27% which, however, is attributable only to the public sector. The public employers' attempt to integrate more women into academic life has been successful to a certain extent. With an 8% increase Germany has played one of the leading roles in an international comparison. In the private sector, however, there has only been a mere 3% increase to 14%.

1.4.5 R&D in the Business Enterprise Sector

In 2013 €53,566.2 million were spent on intramural R&D in the German business enterprise sector – approximately two thirds of all R&D expenditures. After many years of continuous growth, expenditures stagnated for the first time and were at roughly the same level as the previous year, with a slight 0.4% minus.[14] German R&D is dominated by the manufacturing industries, accounting for more than 85% of the entire intramural R&D expenditures in the German business enterprise sector. This makes Germany the undisputed leader among the industrial nations, followed within the EU by Italy, Finland, and Sweden with 70–72%. The end section consists of, inter alia, Norway, with less than a third. Bulgaria brought up the rear with 14%. The other side of the coin is, of course, a correspondingly small proportion of the service sector to the overall German R&D activities.

A breakdown by industries reveals that German R&D is largely dominated by the automotive industry (Fig. 1.5). Nearly a third of all intramural R&D expenditures in 2013 can be attributed to car manufacturers and their suppliers. This value has remained largely unchanged for many years.

As expected, a comparison between Germany and Turkey yields various differences, but also some unanticipated parallels. Similarities include the facts that

- the Turkish business enterprise sector, too, has been steadily growing for many years, albeit in total at a considerably higher rate than the German one.
- with slightly under 9% the growth between 2012 and 2013 was, compared over many years, below-average (as mentioned before, this period saw a stagnation for Germany).

[13] For a detailed structural analysis of women at higher education institutions (including an international comparison) cf. Ihsen (2014).

[14] The Wissenschaftsstatistik (2015a) provides a comprehensive set of figures on R&D within the German business enterprise sector. Analyses into that matter can be found in Wissenschaftsstatistik (2015b).

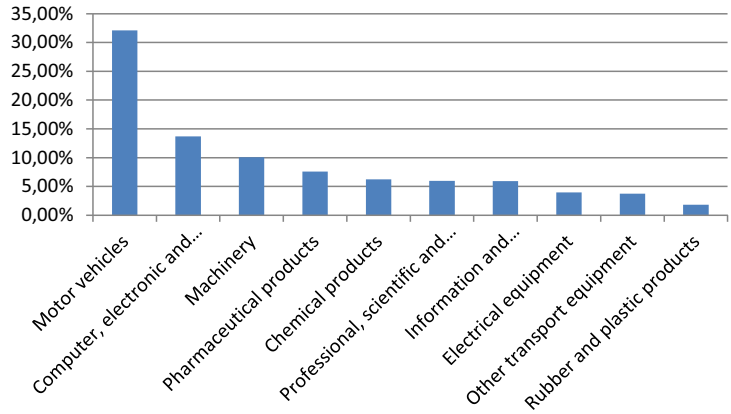

Fig. 1.5 Intramural R&D expenditures in Germany by industries

- both, the German and the Turkish business enterprise sector, were affected by the financial crisis in 2009, however,
  - effectively only in 2009 (both countries had recuperated by 2010),
  - with only a minor slump in both countries.

These parallels are all the more surprising considering the remarkable structural differences between both countries.

The Turkish business enterprise sector is much more characterized by the service industry than its German counterpart. A good 47% of intramural R&D expenditures are attributable to business services.[15] Accordingly, the industry's share amounts to nearly 51%.[16] On the sectoral level Turkish R&D is characterized by information and communication activities, as well as technical service providers[17], more so than by traditional industries such as the manufacture of motor vehicles, the manufacture of chemicals, the manufacture of electrical and optical equipment, and the manufacture of machinery (Fig. 1.6).

Another noteworthy aspect of the inter-country comparison are the relative research costs, i.e. the amount of intramural R&D expenditures per researcher. In Germany these are almost four times as high as in Turkey (€270,000 and €70,000, respectively), with a wide span in both countries due to differences in the capital intensity of research within individual sectors. With €572,000 per researcher in Germany and slightly over €100,000 in Turkey, pharmaceutical research constitutes the most expensive field in both countries. It is also interesting to note that information and communication activities is one of the

[15] Sections G–N in NACE 2.0.
[16] The agricultural and mining sectors are entirely missing.
[17] NACE 2.0 section M.

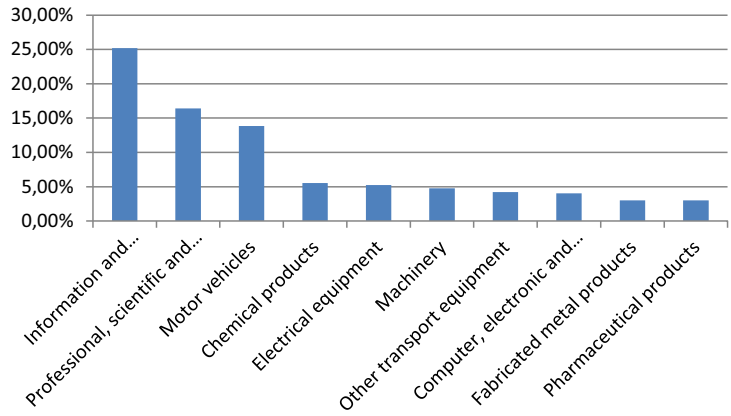

Fig. 1.6 Intramural R&D expenditures in Turkey by industries

most expensive research fields in Germany (with more than €300,000 per researcher), whereas in Turkey it represents the least expensive area (€45,000 per researcher).

1.4.6 R&D in the Higher Education Sector

The German Higher Education Sector

There are 428 higher education institutions in Germany, including 108 universities.[18] In 2013 99,123 FTEs were employed in the higher education sector. €14,301 million were spent on research and development.[19] The German research landscape is mostly medical-, science- and technology-oriented (Fig. 1.7). The MINT subjects and medicine account for a good three quarters of all intramural R&D. It should, however, be noted that research in these subjects is usually considerably more cost-intensive than, for example, in the humanities or social sciences. Accordingly, R&D personnel is a factor to be taken into account. However, even this indicator yields the result that the medical-, science- and technology-based subjects are dominating the higher education sector, accounting for two thirds of all R&D personnel.[20]

The Turkish Higher Education Sector

The Turkish universities are quite young. Just 10 out of 173 universities are older than 59 years.[21]

[18] https://de.wikipedia.org/wiki/Liste_der_Hochschulen_in_Deutschland.
[19] On the methodology of R&D surveys within the higher education sector cf. Statistisches Bundesamt (2013).
[20] However, only 44 % of all students are attributable to these subjects.
[21] https://de.wikipedia.org/wiki/Liste_der_Universit%C3%A4ten_in_der_T%C3%BCrkei.

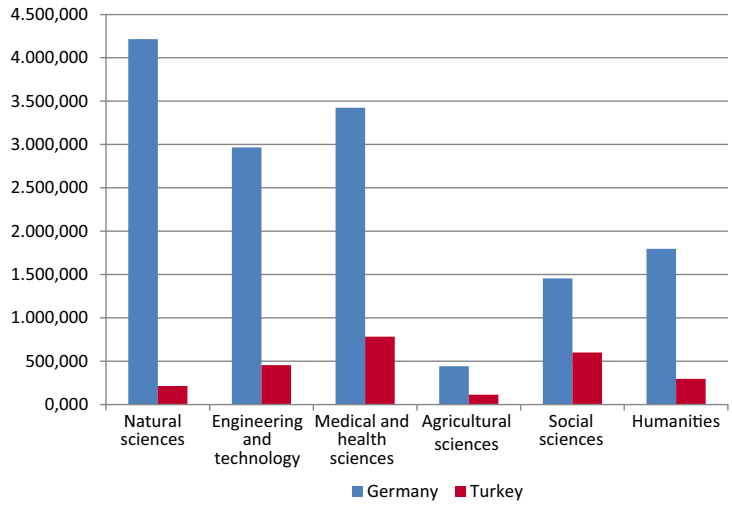

Fig. 1.7 Intramural R&D expenditures in the higher education sector by field of science

Intramural R&D in Turkish higher education institutions amounted to slightly under €2.5 billion in 2013, with a particularly high level of self-financing (48%; not counting third-party funds as done in the business enterprise sector, but self-generated funding, e.g. tuition fees). This is attributable to the large number of private universities (66 out of 173, plus 4 institutions of the Turkish armed forces). For comparison only, in most industrial nations far less than 10% of all R&D expenditures are self-financed. Only Japan compares to Turkey in that aspect (43%).

Research in the Turkish higher education sector rests on two pillars: medicine, accounting for almost a third of all research funds and 25% of all R&D personnel, and – rather unusually – the social sciences, making up almost 25% of all intramural R&D. Hardly any other industrial nation exceeds 20% in this category, thus highlighting the significance of the social sciences for the Turkish higher education sector.

Conclusion

In 2002, Germany, along with the other EU countries, made a commitment to demonstrating intramural R&D expenditure numbers in the amount of 3% of the gross domestic product by 2010. Despite a good starting position (in 2002 the expenditure-to-GDP relation was 2.42%[22]) progress was lagging, and the ratio reached a mere 2.71% by 2010, and, despite a growing trend, only 2.83% by 2013. It should, however, be mentioned that German policy makers have always taken this target rather seriously without ever losing sight of it, and that there has been at least an approximation in Ger-

[22] All GDP relations take into consideration the national accounts revision under the SNA 2008.

many, whereas in several other EU countries there has been no progress whatsoever or even a deterioration, meaning that ultimately the EU has still a long way to go.

The medium-term objective for Turkey must be an increase in the amount of research and development to a level comparable to that of leading industrial nations. This, however, calls for an immense effort in all sectors. It is mostly the business enterprise sector that requires adjustment, but also the other sectors' R&D is still considerably short of what can usually be expected of a modern industrial nation.

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