Business R&D in Poland –
The Role
of the Economic Structure

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Abstract

In this paper we deal with the structural characteristics of R&D in the Polish business enterprise sector; specifically, the paper seeks to contribute to the development of explanatory approaches for the extraordinary weak performance in Polish business R&D. Therefore, three different factors are examined in this context: (1) the industrial composition of the Polish economy, (2) the role of firm sizes and (3) the influence of foreign multinational companies in Poland. Additionally, a regional perspective is chosen in order to increase the data set and complement the findings at the national level. The paper shows that the low aggregate level of business R&D in Poland can be to a substantial part due to the country’s relatively weak domestic industrial basis, especially in the high- and medium/high-tech sectors as well as knowledge intensive services. Furthermore, it reveals that the lack of large domestic companies in those R&D-intensive sectors also contributes to the low level of R&D expenditures. Finally, there are some hints that foreign-controlled affiliates in Poland actually lower the level of the country’s aggregate R&D intensity. In conclusion, this paper suggests to stronger take into account such framework conditions in ongoing policy debates and political decision-making at the national as well as at the European level.
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1 Introduction

In 2002, the European Council adopted the so-called “Barcelona target”, which is one of the most prominent outputs of European research policy. The target was established in the context of the Lisbon Strategy and stands for an increase of R&D spending up to 3 percent of the gross domestic product (GDP) by 2010, whereas two-third of it shall be ideally funded by the private sector. A (closer) look at the respective figures reveals that the European Union and most of its member states have obviously failed to achieve this ambitious goal. However, the European leadership was not willing to dismiss this idea when revising the expiring Lisbon Strategy and setting up the new Europe 2020 strategy in 2010, widely relying on the same policies and policy mechanisms. Though, nearly all European policy makers regularly emphasise the importance of R&D and innovation for the future development of their countries as well as the prosperity of the whole European Union, the “3 percent target” itself is controversial. Some members of the Polish government recently questioned the sense of this target pointing at the large differences between their country (and other new member states which are still in the transformation process) and some of the old member states that are far ahead when it comes to technological capacities.\(^1\) Indeed, having in mind Poland’s R&D and innovative performance, one can wonder whether the 3 percent target is a realistic option for the country within the next ten years. In most of the countries with a R&D spending rate close to or above 3 percent of their GDPs, approximately two-thirds are funded by the business enterprise sector (as desired by the Barcelona target).\(^2\) Yet, that is the weakest point concerning Polish R&D performance as the business enterprise sector in Poland is still characterised by a very poor performance in essential innovation-related areas. In that context, Polish companies remain far below the EU-27 average and, in addition to that, the distance to the leading EU member states is even much larger. This is shown, for instance, by the *European Innovation Scoreboard 2008*, according to which Poland continues being one of the so-called “catching-up countries”. Compared to other European countries, Polish companies generally invest very little in research and development (see Figure 1). In contrast to the Barcelona target, public sector research institutes are still responsible for the clear majority of R&D activities in Poland (see Figure 2). Accordingly, about two-thirds of the Polish R&D expenditures were spent

\(^1\) See Euractiv (2010).
\(^2\) That applies, for instance, to Germany, Finland, Sweden, the U.S., South Korea and Japan (see Eurostat database, reference year: 2007).
in higher-education institutions, the institutions of the Polish Academy of Sciences (PAS) as well as the governmental R&D units (JBR-facilities) in 2007.

What can actually explain the very limited R&D activities of the Polish enterprise sector? And does it really make sense to apply one single quantitative target to 27 countries that differ tremendously from each other in many aspects of socio-economic development? Of course, one can argue that it is a political decision, which is not even binding and, thus, a reluctance of the member states to comply cannot be sanctioned. But is it really the reluctance of Polish political decision-makers that prevents the country from stepping forward in terms of increasing R&D activities? Or is it rather the structure of the economy that plays an important role to explain Poland’s poor business R&D performance?

In this paper we analyse—from a macro-level perspective—the R&D activities of the Polish business enterprise sector (mainly in terms of expenditures) and its linkages to the country’s economic structure. There exist many approaches to explain the weak performances of Polish enterprises when it comes to R&D and innovation. Surveys, for instance, showed little interest of many Polish entrepreneurs in R&D and innovation (especially smaller and medium-sized enterprises); in more peripheral regions such as Warmińsko-Mazurskie voivodeship in the north of Poland 40 percent of the examined entrepreneurs even showed some kind of objection towards innovation.\(^3\) Furthermore, entrepreneurs, who implemented innovative solutions, do often not demand R&D; according to data of the European Community Innovation Survey (CIS), in 2006, Czech companies invested nearly four times more of their innovation expenditures\(^4\) into R&D activities than Polish did.\(^5\) Taking into account the even more significant difference between Poland and Western European innovation leaders such as Sweden, this relation might reflect different stages of the enterprises’ modernisation efforts. Without any doubts, these aspects are of high importance in order to understand the big differences in the economies’ demand for R&D. However, in this paper we will focus on another decisive factor that might help to shed some light on the current situation: the structure of the Polish economy and its influence on the extent of R&D activities in the country.

\(^4\) Besides R&D innovation expenditures, among others, also comprises the acquisition of external knowledge (e.g. licenses or patents), machinery, and equipment or technologies. For a detailed definition and description of innovation expenditures as well as of the borderline between R&D and non-R&D innovation expenditures see OECD/Eurostat (2005): pp. 91.
\(^5\) Companies in Western European countries such as Sweden invested even almost eight times more (see CIS 2006).
Figure 1: Total R&D expenditures of business enterprise sector (BERD) in Poland and other selected European countries (2007), percentages of GDP

Source: Author’s illustration; Eurostat database.

2 R&D in the Polish Enterprise Sector

Basically, the importance of innovation in general and, above all, R&D in particular appear to be rather low to Polish enterprises. It is widely known that the biggest part of the R&D expenditures in Poland is, unlike in many western countries, neither spent for nor funded by the enterprise sector. But also compared to other Central and Eastern European countries (CEECs), Poland’s business R&D expenditures are low (see Figure 1). Instead, a clear majority of R&D activities is still conducted by the research institutions of the public sector and does not involve the enterprise sector – contrary to the above mentioned Barcelona target. In 2007, nearly 60 percent of the R&D expenditures were allocated from the Polish state budget, whereas only about one-third was provided by the business enterprise sector (see Figure 2). Correspondingly, the major R&D performing actors are public institutions: higher education institutions (HEIs), the Polish Academy of Sciences (PAS) and the so-called branch research-development units (JBRs) can be regarded as the key players of the Polish R&D landscape (see Figure 3).
Figure 2: R&D expenditures in Poland by source of funds (2007), in percent of total R&D expenditures

A comparison of Figure 2 and Figure 3 indicates that, although slightly more than one-third of the total R&D expenditures come from the business enterprise sector, only one-fifth is actually spent on R&D activities in this field. This discrepancy reflects the part of extramural business R&D expenditures. In fact, 33 percent of the total business R&D expenditures account for extramural R&D according to the results of the latest Community Innovation Survey (CIS for the year 2006). That is a higher rate than in some other European countries such as in Romania (16 percent), and even in the Netherlands (23 percent) and Sweden (25 percent) the ratios of extra- to intramural R&D are below. But in the same time, Polish companies only spend 13 percent of their total innovation expenditures for R&D activities, whereas, for instance, in Romania it is 16 percent, in the Czech Republic 42 percent and in Western European countries such as Sweden the rate is 80 percent. Additionally, the level of innovation expenditures in general remains far below those of other CEECs: in the Czech enterprise sector, for instance, in 2006 about EUR 328 per capita accounted for innovation expenditures, whereas the Polish enterprises only spend EUR 129 per capita for innovative solutions.

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6 Own calculations based on CIS (2006).
7 Own calculations based on the data of the Community Innovation Survey (CIS) for 2006. Regarding Sweden as one of the major European innovation leaders this amounts to EUR 1.323 per capita.
Figure 3: Gross domestic expenditures on R&D activity by type of units (2007), in percent of total R&D expenditures

What could be possible factors determining this extraordinary weak performance in R&D expenditures? First of all, the low spending on R&D by Polish firms does not necessarily imply a generally low interest of Polish entrepreneurs in implementing innovation. Of course, surveys showed that many Polish entrepreneurs considered the price of the product or service they offer and not innovation as the main component of their competitiveness (this applies particularly to SMEs).\(^8\) And the figures above show that in terms of innovation expenditures Polish firms are lagging far behind other CEECs. However, there are diverse factors which can partly explain the low level of Poland’s business R&D expenditures. In many cases, the lack of finance certainly plays an important role, although recent findings suggest that the overall situation has improved over the past years, partly due to the significant inflow of capital from the European Union. Nevertheless, the underdeveloped venture capital market in Poland – venture capital has often proved to be an essential driving factor for the innovative dynamics of an economy – is still a problem.\(^9\) Without neglecting those factors and their influence on the innovative capacities of Poland, this paper concentrates on the explanatory power of the structure of the Polish enterprise sector for the country’s business R&D. Generally speaking, it seems there are three prevailing themes in this context:

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\(^{8}\) See OECD (2007).
\(^{9}\) See European Commission (2009).
1) The composition of the Polish economy: strong focus on low and medium low- 
technology manufacturing and less knowledge-intensive services;

2) Few large domestic firms that might significantly affect the size of aggregate 
R&D;

3) Strong engagement of foreign multinational companies that conduct little R&D in 
Poland.

In the following chapters each aspect will be discussed separately in order to identify its poten-
tial explanatory value. In this paper we cannot provide a full-scale (micro-) analysis; our 
goal is rather to contribute to the ongoing scientific and political dispute in terms of delivering 
inputs for further analyses.

2.1 The Data

All data referred to in this paper are taken from the databases and publications of:

- Eurostat database,
- OECD database,
- Central Statistical Office of Poland.

The reference year is in most cases 2007, mainly due to the availability of the data in the field of science and technology. In order to systematically capture the sector-specific data in a comparable manner, the Statistical Classification of Economic Activities in the European Community, Revision 1.1 (NACE Rev. 1.1) referring to the Eurostat data and the International Standard Industrial Classification of All Economic Activities, Revision 3 (ISIC Rev. 3) referring to the OECD data has been used. Both classification systems are – with regard to the two-digit-level – widely in accordance with each other. However, to avoid any distortions, calculations have been conducted only within one classification system. This also applies to the explanations and calculations involving CIS data. Concerning the term “R&D intensity”, the following definitions as well as OECD and Eurostat databases have been used:

\[
\text{(1) } R&D \text{ intensity}_i = \frac{\text{business R&D expenditures}_i}{\text{value added}_i}, \quad i = \text{sector of economic activity},
\]

\[
\text{(2) } R&D \text{ intensity}_v = \frac{\text{business R&D expenditures}_v}{\text{gross domestic product}_v}, \quad v = \text{voivodeship}.
\]

Whereas the first term expresses the sectoral R&D intensity, the second one expresses the regional R&D intensity. The regional analysis comprises the 16 Polish voivodeships (NUTS-
2 level). Though a less aggregated level in terms of smaller geographical units would be desirable, only this allows for a sufficient access to the data, which are necessary for the purpose followed in this paper.

2.2 Appraising the structural characteristics of Polish Business R&D

2.2.1 Structure of Economic Sectors

Why should the industrial composition be regarded at all when examining a country’s or region’s business R&D? It is widely known that different industries involve different levels of R&D activities. Correspondingly, one might expect that aggregate R&D expenditures are affected by the extent to which more and less R&D-intensive sectors are present. Former scientific micro-analyses showed that a substantial part of the differences of R&D intensities across firms can be traced back to the industry the particular firm belongs to. That raises the question whether and to which extent this factor plays a role for the Polish business R&D.

Initially it should be stated that in Poland – unlike in both highly industrialised countries as well as in other CEECs such as the Czech Republic or Hungary – the ratio of R&D expenditures in manufacturing in comparison to those in services is visibly greater than one. A first breakdown of the Polish business R&D expenditures, however, reveals that both economic sectors account for nearly the same when it comes to R&D spending. In 2007, the manufacturing accounted for 51 percent and services for 48 percent of the total business R&D expenditures of EUR 535 Mio, which made up 0.17 percent of the Polish GDP. Given their marginally low contribution to the country’s R&D spending, further economic sectors are not considered in this paper.

First of all, the manufacturing sector that in most cases is the typical driver of business R&D shall be subject to a closer look. Figure 4 indicates the distribution of the R&D expenditures in the manufacturing sector by more detailed economic activities. Referring to absolute values, there exist four dominant economic sectors, which combined account for nearly 70 per-

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11 In fact, most countries with a high overall business R&D intensity are also characterised by strong industrial bases which obviously contribute more to their aggregate business R&D intensity than the service sector. Among them are Germany, Sweden, Finland, the USA, Japan, and South Korea.
12 cent of the total business R&D spending in Poland; *electrical and optical equipment*, *chemicals and chemical products*, *transport equipment* and *machinery and equipment*. This is not very surprising, given the fact that within the manufacturing sector those economic activities traditionally involve more R&D activities than others. A big difference regarding the structure of business R&D in the manufacturing sector rather shows up when it comes to the intensity of R&D expenditures and the relative importance of the respective economic sector, i.e. its contribution to the country’s gross value added (GVA). The above mentioned four economic sectors also appear to have the highest R&D intensities compared to other manufacturing sectors in Poland. However, both the level of R&D intensities as well as the sector-specific GVA remain extraordinary low and are not only far below those of innovation leaders such as Germany but also those of other CEECs, e.g. the Czech Republic (see Appendix 1 and Appendix 2).

**Figure 4: R&D expenditures in the manufacturing sector by economic activity (2007), percentages of total R&D expenditures in the manufacturing sector**

![Pie chart showing R&D expenditures by economic activity in the manufacturing sector (2007)](chart)

Source: Author’s illustration; Eurostat database.

12 Manufacture of electrical and optical equipment consists of manufacture of office machinery and computers; ~ electrical machinery and apparatus n.e.c.; ~ radio, television, and communication equipment and apparatus; ~ medical, precision and optical instruments, watches and clocks.

13 The major driver here is the pharmaceutical industry. Almost 70 percent of the R&D expenditures in manufacturing of chemicals and chemical products is spent there.
Figure 5 positions the examined manufacturing sectors (2-digits-level) on four quadrants demarcated by the average values of the R&D intensities and the GVA, respectively. Quadrant I comprises those economic sectors which are characterised by a R&D intensity above and a GVA share below the country’s average and, thus, cannot largely contribute to the aggregate R&D intensity. In quadrant II the major “R&D drivers” are located; their production is relatively R&D-intensive (as concerns Poland) and their economic importance in terms of its GVA share is above average. The other sectors in quadrant III and IV do either not or hardly spend anything on R&D activities or only add a small amount to the aggregate R&D expenditures due to their relative size. The biggest manufacturing sector, namely food products and beverages, is a striking example; though it has one of the lowest R&D intensities, it accounts for more of the total R&D expenditures in manufacturing than other transport equipment, which is the country’s most R&D-intensive sector. Hence this qualifies as a pure “volume effect”.

In other countries such as Germany or the Czech Republic, for instance, a completely different picture can be observed (see Appendix 1). There (1) the average R&D intensities and (2) the contribution of those sectors that show a R&D intensity above the average are significantly higher than in Poland. In fact, the two biggest manufacturing sectors of Poland – food products and beverages and fabricated metal products – show some of the lowest R&D intensities. Whereas in Germany machinery and equipment (though slightly below the German average in R&D intensity), motor vehicles, trailers, and semi-trailers as well as chemicals and chemical products are the biggest manufacturing sectors. Especially the latter has a R&D intensity that lies above the country’s average and significantly above the Polish average. The same applies to their GVA share. But also machinery and equipment show a R&D intensity even above Poland’s most R&D-intensive sector.

14 The upper left is quadrant one (others by clockwise direction).
Besides manufacturing the service sector as a whole plays a major role for the Polish business R&D activities. However, a closer look at the distribution of R&D expenditures on specific economic activities reveals why the service sector accounts for nearly half of all business R&D expenditures: the branch research and development makes up over 70 percent and, thus, is the main reason for the relatively high level of R&D expenditures in the service sector (see Figure 6). About 40 percent of the R&D expenditures spent in this branch is funded by the Polish government and sources from abroad (i.e. first of all, the European Union). For that reason, the R&D spending in the service sector shows a significantly higher rate of state funding than in manufacturing. Apart from research and development, computer and related services appears as dominant factor when it comes to investments into R&D within the service sector. But also regarding the whole business sector, this branch of economic activity adds some substantial part to the Polish business R&D activities. In absolute figures software

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15 This figure is based on data from 2006 since data from 2007 were not available yet. When comparing figure 4 and 5, one can see that electrical machinery and apparatus actually accounts for more of the total R&D expenditures and in the same time shows nearly the same R&D intensity but a lower GVA share. These frictions can be traced back to different years. Unfortunately, the data are not complete for 2006.

16 The rate of public funding of business R&D in manufacturing is the highest in other transport equipment (e.g. aircraft and spacecraft).
consultancy and supply services, for instance, invest almost as much into R&D as the pharmaceutical industry in Poland does. 17

Finally, in the service sector one can observe the same phenomenon as in manufacturing: there are no major drivers for the R&D activities either. The most R&D-intensive branch within the service sector is real estate, renting, and business activities (due to research and development) and that, again, remains on a relatively low level regarding its gross value added (see Figure 7). In Germany and the Czech Republic, for instance, real estate, renting, and business activities is larger (especially in Germany) and significantly more R&D-intensive (especially in the Czech Republic) than in Poland. Nevertheless, in both countries the service sector performs much less R&D compared to the manufacturing sector. That applies particularly to (West) Germany with its traditionally strong and highly developed industrial base. 18

Figure 6: R&D expenditures in the Polish service sector by economic activity (2007), in percent of total business R&D expenditures in the service sector

Source: Author’s calculations; Eurostat database. G comprises wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods; L to Q comprises public administration and defence; compulsory social security; education; health and social work; other community, social and personal service activities; activities of households; extra-

17 Though there are no data available as regards the GVA of both branches, employment data indicate that software consultancy and supply services is significantly larger than pharmaceuticals and, thus, the latter is likely to be more R&D-intensive.
18 See Stifterverband für die Deutsche Wissenschaft (2010).
terриториальных организаций и телекоммуникаций. I60 to I64 (not I642) comprises transport, storage, and communication without telecommunications.

**Figure 7: R&D intensities and GVA shares in the Polish service sector by economic activity (2007), in percent**

![Diagram showing R&D intensities and GVA shares](image)

Source: Author’s illustration; Eurostat database.

What has been observed so far? Obviously, in this context there are two factors that keep Poland’s aggregate business R&D (as concerns manufacturing) down: the low level of R&D intensities on the one hand and the small size (in terms of GVA) of the relatively R&D-intensive sectors in Poland on the other hand. The latter exactly hints on the first presumption of this paper; Poland’s knowledge-intensive production and services appear to be rather weak in comparison to other European countries including CEECs. The figures in Table 1 confirm these findings. Both in manufacturing as well as in services the relative economic importance (expressed by the GVA ratios) of the sectors, which are characterised by a higher knowledge-intensity, remains below those of other European countries. Given that knowledge-intensity is measured by R&D intensity, these findings provide one important reason for the extraordinary low level of business R&D in Poland. In other words, the structure of the Polish economy is one important explanation for the lack of R&D investments in the enterprise sector: the tradi-
tionally more R&D-intensive economic sectors (such as pharmaceuticals or electrical and optical equipment) only play a minor role in the Polish economy. Instead, it is rather dominated by low and medium low technology manufacturing and less-knowledge intensive services.

Table 1: Shares of sectoral GVAs in total GVA in selected European countries (2006)

<table>
<thead>
<tr>
<th>Economic Sectors</th>
<th>Germany</th>
<th>Poland</th>
<th>Czech Republic</th>
<th>Hungary</th>
<th>Romania</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>21.91%</td>
<td>19.01%</td>
<td>25.82%</td>
<td>22.12%</td>
<td>12.59%</td>
</tr>
<tr>
<td>High-tech sectors (high-tech manufacturing and knowledge-intensive high-technology services)</td>
<td>6.71%</td>
<td>4.78%</td>
<td>6.47%</td>
<td>8.55%</td>
<td>4.16%</td>
</tr>
<tr>
<td>High technology manufacturing sector</td>
<td>2.64%</td>
<td>1.17%</td>
<td>1.79%</td>
<td>4.14%</td>
<td>0.58%</td>
</tr>
<tr>
<td>Low technology manufacturing sector</td>
<td>4.28%</td>
<td>6.95%</td>
<td>No data</td>
<td>No data</td>
<td>5.44%</td>
</tr>
<tr>
<td>Medium high technology manufacturing sector</td>
<td>9.85%</td>
<td>5.01%</td>
<td>9.66%</td>
<td>7.68%</td>
<td>2.94%</td>
</tr>
<tr>
<td>Medium low technology manufacturing sector</td>
<td>5.13%</td>
<td>5.87%</td>
<td>8.16%</td>
<td>5.46%</td>
<td>3.64%</td>
</tr>
<tr>
<td>Knowledge-intensive high-technology services</td>
<td>4.07%</td>
<td>3.60%</td>
<td>4.67%</td>
<td>4.41%</td>
<td>3.58%</td>
</tr>
<tr>
<td>Knowledge-intensive market services (excluding financial intermediation and high-tech services)</td>
<td>10.06%</td>
<td>6.09%</td>
<td>No data</td>
<td>7.07%</td>
<td>3.72%</td>
</tr>
<tr>
<td>Less-knowledge-intensive market services</td>
<td>13.86%</td>
<td>15.62%</td>
<td>16.59%</td>
<td>14.66%</td>
<td>11.81%</td>
</tr>
</tbody>
</table>

Source: Eurostat database.

However, not only a certain kind of “negative volume effect” can be observed, i.e. the more R&D-intensive sectors’ contribution to the country’s GVA is below average. Additionally, even in these sectors the intensity rates of R&D performance remain far below those of other European countries (see Appendix 4). Admittedly, this does not seem to be explainable by the economic structure. It might be rather due to other factors mentioned above, such as firm size and activities of foreign multinational companies producing in Poland (see section 2.2.3).
2.2.2 Firm Size

The distribution of a country’s or region’s companies across different size classes is frequently regarded as one factor determining the level of its business R&D expenditures. It is often believed that bigger firms are able to invest more into R&D due to their extended capital base and their better access to (external) financial sources. However, for many countries there is rather little empirical evidence in support of a significant positive correlation between the size of a firm and its R&D expenditures.19 But what can be observed for Poland in this context?

First and foremost, as in many other countries the vast majority of Polish enterprises belongs to the category of small and medium-sized enterprises (SME): 95 percent of all Polish firms are micro-enterprises, 4 percent are small enterprises, less than 1 percent are medium-sized enterprises and only 0.14 percent belong to the category “large enterprises”.20 In the same time, these enterprises generate one-third of the Polish GDP (2007) and employ 31 percent of all working people in Poland. Whereas micro-enterprises do not even invest 1 percent of the total business R&D expenditures in Poland, large companies account for 67 percent. Figure 8 shows that, in absolute values, bigger enterprises contribute more to the country’s business R&D performance than smaller ones.

Figure 8: R&D expenditures in the Polish Enterprise Sector by size classes (2007), percent of total BERD

Source: Author’s calculations; Eurostat database.

20 See Polish Agency of Enterprise Development. The categories are divided according to the firms’ employees as follows: 0-9 (micro), 10-49 (small), 50-249 (medium) and 250 and more (large).
Figure 9 illustrates the enterprises’ R&D expenditures as percentages of their total innovation expenditures. Here the positive relation between the firm size and the extent of its R&D investments is not as clear as it appears when regarding the contribution to the country’s total R&D expenditures. As expected, bigger companies show the highest R&D spending rates relative to their total innovation budget. But the difference to small enterprises is rather negligible. The small companies even allocate more of their innovation budgets towards R&D activities than medium-sized ones. As already mentioned in the beginning, the ratio of R&D and innovation expenditures in Poland is far below the one in other European countries including CEECs.

Whereas only a slight difference between large and small companies in Poland regarding the R&D expenditures as relative parts of the innovation expenditures can be observed, Figure 10 draws another picture. Particularly between the categories small and large, there is some visible gap: in relation to their revenues large companies invest nearly four times more into R&D than small companies. As also shown in Figure 10, this implies that large companies – regarded on an aggregated level – spend more of their total revenues on innovation expenditures than small ones do. The same relation applies to the R&D expenditures.

**Figure 9: Business R&D expenditures by size classes in Poland (2006), as percentage of total innovation expenditures**

![Figure 9: Business R&D expenditures by size classes in Poland (2006), as percentage of total innovation expenditures](image)

Source: Author’s calculations; CIS 2006.

21 That particularly holds true when comparing the situation in some Western European countries (such as the Netherlands) where small enterprises invest 49 percent of their total innovation expenditures into R&D and large ones 86 percent.
Yet, what can be said about the relation between R&D intensity and firm size when it is measured across different sectors of economic activity? In other words, does a higher share of large firms in one specific economic sector go along with a higher R&D intensity in that sector? For the year 2006, the analysis of 26 economic sectors yields, for all five size classes, correlation coefficients that are close to zero. Hence an economic sector that shows a high share of large firms does not necessarily have a higher R&D intensity, too. Analysing a sample of firms within one specific economic branch might, for instance, reveal negative or positive impacts on the intensity of R&D investment. Nevertheless, the above described findings (extended to 4 years – 2003 to 2006) illustrated in Figure 11 clearly show that there is no statistical relation between the firm size and R&D intensity when considering the aggregate data across the economic sectors in manufacturing and services. Again, it is important to note that these findings are based on the analysis of aggregate secondary data provided by the OECD database whose explanatory power is limited. As a result of this, broad conclusions about the “size effect” in Poland cannot be made.
Figure 11: R&D intensities and share of large firms by sector of economic activity (2003-2006), in percent

Source: Author’s illustration; OECD database.

Concluding, from an overall perspective the firm size might play a certain role for the level of R&D and innovation expenditures in Poland, although the intensity of this relation and further framework conditions that it might really affect R&D are not clear. For other countries, empirical studies show that the specificities of this relation highly depend on other factors such as the economic branch in focus. For an international sample of high-tech firms, for instance, a statistically significant relationship has been found between the firm size and the R&D intensity in personnel and investment which is negative. In other industries such as plastics and metals no correlation could be found. Thus, further empirical studies on the firm level (e.g. specifically focusing on certain branches) in Poland are needed in order to get a detailed and empirically meaningful picture of the impacts of firm sizes. However, regarding the results mentioned above (before taking into account economic sectors), it makes sense to look at the firm size’s influence when it comes to the regional distribution of business R&D within Poland (see section 2.3).

22 Take, for instance, a high-tech start-up in the pharmaceutical or biotech sector where R&D expenditures often account for an enormous part of the firm’s overall budget. This can be due to the high knowledgeintensity of the development and commercialisation of its product. Correspondingly, as concerns such sectors it seems to be plausible when the R&D intensity at the firm level is higher in smaller firms.

2.2.3 Multinational companies

Basically, it depends on different factors whether foreign affiliates conduct R&D in their host countries or not. These are, among others, market potential, the availability of highly qualified personnel, the proximity to regional research infrastructure, and the sufficiency of intellectual property protection. Although the question about framework conditions that attract high value activities such as R&D from international investors is of great importance, for instance, to national and regional policy makers, it will not be discussed in this paper. In fact, further research in this field, particularly as concerns Poland, might provide some detailed and country-specific insights and provide researchers as well as policy makers with valuable information. Yet, one aim of this paper is to find some evidence on the influence of multinationals companies (MNCs) on the aggregate R&D intensity of Poland.

So far, foreign MNCs operating and investing in the Polish market conducted only little R&D in Poland. Instead, the biggest part of the R&D investments – especially those which can be referred to as basic or strategic R&D and are extraordinarily research-intensive – was made in their home countries or in other highly industrialised countries. That might partly explain the low levels of R&D intensities in many economic sectors that usually are significantly more R&D-intensive, if compared to other countries in Western Europe but also in CEE (see Appendix 4). Given the R&D intensity as the ratio of R&D expenditures and sectoral value added/ regional GDP, especially large MNCs visibly contribute to the denominator but – in relative terms – hardly do so when it comes to the nominator. Consequently, MNCs that do not conduct large-scale R&D projects in Poland are likely to lower the aggregate R&D intensity of the country or region. Indeed, the available macro data taken from the Eurostat database back this argument; the statistics on foreign controlled enterprises in Poland draw an interesting picture. Accordingly, exactly those industrial sectors that generally are R&D-intensive and in fact are also the most R&D-intensive in Poland (i.e. high and medium high-tech manufacturing) indicate the highest rates of foreign control.

24 Distinguishing between “demand-driven R&D” and “supply-side R&D” allows for further systematisation and differentiation of driving factors for the internationalization of R&D and, thus, for the level of R&D investments of multinationals in their host countries (see Narula, R. (2009)).


26 Control is defined as “[…] the ability to determine the general policy of an enterprise by choosing appropriate directors, if necessary” (Eurostat (2007): p. 16).
Table 2 shows that affiliates of foreign companies dominate more or less the three manufacturing sectors which are above the country’s average in terms of contribution to the economy’s GVA as well as in terms of their R&D intensities.\textsuperscript{27} This applies, above all, to the automotive industry where foreign-controlled companies create half of the sector’s employment and even more than 80 percent of the sector’s GVA.

\textsuperscript{27} A very similar situation can be observed in Canada: “[…] many of Canada’s large, technically-advanced firms are affiliates of foreign (usually U.S.) multinationals. … The auto industry is a striking example.” (Iorwerth, A. (2005)).
Table 2: Share of persons employed by foreign-controlled companies in Poland by sector of economic activity (2007), in percent

<table>
<thead>
<tr>
<th>Sector of economic activity</th>
<th>Share of persons employed by foreign controlled companies</th>
<th>Share of value added generated by foreign controlled companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing (total)</td>
<td>21.03%</td>
<td>41.72%</td>
</tr>
<tr>
<td>Manufacture of food products; beverages and tobacco</td>
<td>15.05%</td>
<td>45.83%</td>
</tr>
<tr>
<td>Manufacture of textiles and textile products</td>
<td>10.21%</td>
<td>18.88%</td>
</tr>
<tr>
<td>Manufacture of leather and leather products</td>
<td>7.67%</td>
<td>11.92%</td>
</tr>
<tr>
<td>Manufacture of wood and wood products</td>
<td>8.19%</td>
<td>30.31%</td>
</tr>
<tr>
<td>Manufacture of pulp, paper and paper products; publishing and printing</td>
<td>18.42%</td>
<td>41.61%</td>
</tr>
<tr>
<td>Manufacture of coke, refined petroleum products, and nuclear fuel</td>
<td>1.65%</td>
<td>2.12%</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Manufacture of chemicals, chemical products, and man-made fibres</td>
<td>29.00%</td>
<td>43.80%</td>
</tr>
<tr>
<td>Manufacture of rubber and plastic products</td>
<td>34.82%</td>
<td>45.48%</td>
</tr>
<tr>
<td>Manufacture of other non-metallic mineral products</td>
<td>19.22%</td>
<td>48.31%</td>
</tr>
<tr>
<td>Manufacture of basic metals and fabricated metal products</td>
<td>18.04%</td>
<td>36.24%</td>
</tr>
<tr>
<td>Manufacture of machinery and equipment n.e.c.</td>
<td>20.24%</td>
<td>31.35%</td>
</tr>
<tr>
<td>Manufacture of office machinery and computers</td>
<td>26.21%</td>
<td>4.17%</td>
</tr>
<tr>
<td>Manufacture of electrical machinery and apparatus n.e.c.</td>
<td>48.05%</td>
<td>49.69%</td>
</tr>
<tr>
<td>Manufacture of radio, television and communication equipment and apparatus</td>
<td>47.43%</td>
<td>58.54%</td>
</tr>
<tr>
<td>Manufacture of medical, precision and optical instruments, watches and clocks</td>
<td>26.54%</td>
<td>26.16%</td>
</tr>
<tr>
<td>Manufacture of motor vehicles, trailers and semi-trailers</td>
<td>50.48%</td>
<td>82.41%</td>
</tr>
<tr>
<td>Manufacture of other transport equipment</td>
<td>17.44%</td>
<td>23.88%</td>
</tr>
<tr>
<td>Manufacturing n.e.c.</td>
<td>17.91%</td>
<td>30.26%</td>
</tr>
</tbody>
</table>

Source: Author’s calculation; Eurostat database.

But, as Table 2 shows, it is not only the automotive industry that has high rates of foreign control; parts of electrical and optical equipment provide another example of industrial sectors that are among the most R&D-intensive and have a high rate of foreign control. As concerns chemicals and chemical products, the figure is above-average, too. However, there is a big gap between the R&D intensities of the pharmaceutical sector and the others. A strong foreign control of the more R&D-intensive pharmaceuticals would provide further hints in that context.

As for the service sector, it is, as mentioned above, research and development that accounts for the vast majority of R&D expenditures and that is the most R&D-intensive service sector. Here not even two percent of the employees are working for subsidiaries of foreign entities. Also in other relatively R&D-intensive service sectors such as computer and related activities the share of foreign controlled employment is only slightly above the average rate in the service sector (11.2 percent).

To sum it up, the strong presence of foreign MNCs in Poland seems to have some explanatory power concerning the comparably low R&D intensities of the Polish economy. This applies, first and foremost, to the manufacturing sector, more concretely to those manufacturing sec-
tors that generally tend to be R&D-intensive and in fact show a R&D intensity that is above the country’s average. Here the influence of foreign multinationals is the highest. Thus, given that the affiliates of foreign companies typically conduct little R&D in Poland, their illustrated relative weights has to be considered as an important factor that can help to explain the low level of aggregate business R&D in Poland.28

2.3 The regional perspective

In the final step of this paper the distribution of business R&D among the Polish regions is regarded. After depicting the specificities concerning the above mentioned aspects of the economy’s structure (i.e. industrial composition, domestic large firms, and multinationals), a regional perspective is chosen in order to further complement those findings. The regional perspective extends the number of observations and, thus, allows for more detailed empirically testing the explanatory power of two of the three aspects, namely the industrial composition29 and the share of large domestic firms30 in Poland. The third, the influence of MNCs, could not be included due to the lack of necessary data.31

Generally speaking, there are quite big differences between the voivodeships regarding the R&D activities in the enterprise sector. It might not be surprising that the voivodeship Mazowieckie with the Polish capital Warsaw is not only as the major centre of sciences in general; it also lies far ahead at the top of the list as regards the main business R&D indicators such as R&D expenditures and R&D personnel. Figure 12 illustrates parts of the regions’ R&D performances in terms of expenditures in absolute figures and as percentages of the regional GDPs. Obviously, Mazowieckie does not only dominate the country due to its size, i.e. the highest GDP and largest number of employees in Poland, but it shows the highest intensity of R&D expenditures, too. In fact, this hints on what is expressed by the second quadrant; the further voivodeships located there (Malopolskie, Slaskie and Wielkopolskie) are charac-

28 It should be noted that the R&D intensities in major R&D-intensive economic sectors has fallen between 1999 and 2006 (see OECD database). Therefore it would be interesting to know whether the share of foreign-controlled (large) companies in these sectors has risen in the same time period (probably in many cases it has). If yes, it might partly explain the fall in R&D intensity. But when looking at the development of the R&D expenditures in absolute terms, it seems like some other factors also strongly contributed to the decrease of R&D intensities in some industries.

29 The extent of the economic activities has been measured by the share of the sector-specific employment in total employment of the voivodeships (data have been taken from the Eurostat database).

30 The share of large domestic firms in each voivodeship has been calculated on basis of the data provided by the regional databank of the Central Statistical Office of Poland (GUS).

31 Actually, the GUS’ regional databank does provide data about economic entities with foreign capital by voivodeship and size classes. Yet, it is not clear if these enterprises are really foreign controlled.
terised by both R&D expenditures and an R&D intensity above the country’s average. The latter makes clear that the relative high level of R&D investments in those regions cannot mainly be due to an “agglomeration effect”. On the contrary, Pomorskie, for instance, has the second highest R&D intensity and one of the highest R&D expenditures per capita, but in absolute figures it contributes below average to the aggregate level of Polish R&D expenditures.

So far, the picture appears quite clear: some voivodeships with the major urban centres of Poland (mainly in central and southern Poland) make up the main part of the Polish business R&D, whereas others seem to conduct only little R&D activities (mainly in the east, north and west). But what can be found by looking at possible factors determining those different performances within Poland? Here, the above introduced aspects shall be subject to the following remarks.

**Figure 12: R&D expenditures and R&D intensities in the enterprise sector of the Polish voivodeships (2007), in Mio. EUR and percent**

![Graph showing R&D expenditures and R&D intensities in the enterprise sector of the Polish voivodeships (2007), in Mio. EUR and percent](image)

Source: Author’s illustration; Eurostat database.

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32 This would be the case as regards quadrant III.
2.3.1 Structure of Economic Sectors

In order to identify possible impacts of a region’s industrial composition on its R&D intensity, it is necessary to compare the relative weight of those industry and service sectors that are relatively R&D-intensive, i.e. in general, high-tech and medium-high-tech manufacturing as well as knowledge-intensive services. The regional and sectoral employment data given by Eurostat for the years 2004-2007 provide a proxy concerning the regional economic importance of the specific sectors.

First of all, one can observe that the regional R&D intensities are positively correlated to the corresponding extent of economic activity in high-tech manufacturing and services (as for the year 2007 see Table 3). This statement may actually not be very surprising given that the sectors included in the group of high-tech manufacturing and services per se are among the most R&D-intensive. However, it further backs the presumption that the industrial composi-

33 Pearson correlation coefficient is .574; significant at .01 level.
tion seems to have a significant explanatory power when it comes to understand different levels in R&D spending.

On the contrary, the medium-high-tech manufacturing sector appears less appropriate to explain the regional differences in R&D intensity as it shows no correlation. Anyway, comprising relatively R&D-intensive sectors (as concerns the Polish average) such as motor vehicles or machinery, it probably might play a role for the highly industrialised centres in Poland. This particularly applies to the voivodeships Slaskie and Dolnoslaskie where the manufacture of motor vehicles and machinery is strong, but also to Pomorskie that is the leading voivodeship when it comes to the manufacture of other transport equipment (33 percent of the country’s total employment in this sector is registered in Pomorskie).34

Table 3: R&D intensities and employment shares in high-tech manufacturing and high-tech knowledge-intensive services by voivodeship (2007), in percent

<table>
<thead>
<tr>
<th>Voivodeship</th>
<th>R&amp;D intensity</th>
<th>High-tech manufacturing and services employment, share of total employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Łódzkie</td>
<td>0.09</td>
<td>2.57</td>
</tr>
<tr>
<td>Mazowieckie</td>
<td>0.31</td>
<td>5.51</td>
</tr>
<tr>
<td>Małopolskie</td>
<td>0.2</td>
<td>3.31</td>
</tr>
<tr>
<td>Slaskie</td>
<td>0.16</td>
<td>3.24</td>
</tr>
<tr>
<td>Lubelskie</td>
<td>0.07</td>
<td>1.88</td>
</tr>
<tr>
<td>Podkarpackie</td>
<td>0.2</td>
<td>2.19</td>
</tr>
<tr>
<td>Świętokrzyskie</td>
<td>0.07</td>
<td>1.41</td>
</tr>
<tr>
<td>Podlaskie</td>
<td>0.03</td>
<td>2.30</td>
</tr>
<tr>
<td>Wielkopolskie</td>
<td>0.17</td>
<td>2.42</td>
</tr>
<tr>
<td>Zachodniopomorskie</td>
<td>0.01</td>
<td>3.54</td>
</tr>
<tr>
<td>Lubuskie</td>
<td>0.04</td>
<td>1.84</td>
</tr>
<tr>
<td>Dolnoslaskie</td>
<td>0.15</td>
<td>4.28</td>
</tr>
<tr>
<td>Opolskie</td>
<td>0.03</td>
<td>2.33</td>
</tr>
<tr>
<td>Kujawsko-</td>
<td>0.09</td>
<td>2.38</td>
</tr>
<tr>
<td>Warmińsko-</td>
<td>0.1</td>
<td>2.02</td>
</tr>
<tr>
<td>Pomorskie</td>
<td>0.23</td>
<td>4.85</td>
</tr>
</tbody>
</table>

Source: Eurostat database.

As for Mazowieckie, industrial production in general appears to be less important (in relative terms!); not only as regards the structure of its GVA and employment, but also concerning the

34 The manufacture of other transport equipment shows the highest R&D intensity. However, it has to be noted that this sector is very heterogeneous regarding its R&D intensity. Ship-building, for instance, is counted as medium low-tech, motorcycles/bicycles and railway/tramway qualifies as medium-high-tech, whereas aircraft and spacecraft is high-tech.
R&D intensity. The voivodeship including the Polish capital Warsaw is in fact characterised by the – in relative values – smallest industrial sector in Poland in terms of GVA shares (or the second smallest in terms of employment). Instead, the service sector is the predominant one in this region and its GVA share lies far above the country’s average. As already shown in section 2.2.1, R&D expenditures in services are heavily dominated by the sector 73, i.e. research and development; it accounts for 75 percent of the service sector’s R&D expenditures. The fact that again 50 percent of the country’s employees in this sector do actually work in Mazowieckie indicates its high importance for the region’s R&D intensity. Thus, a substantial part of Mazowieckie’s high R&D intensity might be due to the strength in the business sector research and development. Nevertheless, Mazowieckie also shows relatively high employment shares in some major high and medium-high-tech manufacturing sectors as well as in other knowledge-intensive high-tech services (besides research and development). This applies mainly to the manufacturing of electrical and optical equipment, chemicals and chemical products and computer and related services. In addition to that, the manufacturing of chemicals and chemical products in Mazowieckie mainly consists of pharmaceutical industries (which is among the sectors with the highest R&D intensity in Poland) according to the “Agency for Development of Mazovia”.

2.3.2 Large domestic firms

What can be said about the influence of large domestic firms from a regional perspective? Section 0 concluded that on an aggregate level the firm size seems to have some kind of impact on the R&D investments of the company. It has been observed that firms with 250 and more employees in average do invest more of their revenues into R&D activities than medium-sized or even small ones. On the contrary, no statistically significant relation could be found between the R&D intensity and the share of large firms in specific economic sectors. However, assuming that in some economic sectors there is a positive or negative correlation and in others not, it might be possible that at the regional level, i.e. without taking the sector of activity into account, the share of large domestic firms might show some influence on the

35 See Central Statistical Office of Poland GUS (2009a)
36 As regards electrical and optical equipment, it is (1) manufacturing of radio, television and communication equipment and apparatus, where Mazowieckie shows an employment share that lies twice above the country’s average and accounts for one-fourth of the country’s total employment in this sector; and (2) manufacturing of medical, precision and optical instruments, watches and clocks, where the voivodeship also has an employment share nearly of twice above the country’s average and accounts for one fifth of the country’s total employment in this sector.
37 Unfortunately, there are no data available that could support this statement.
aggregate R&D intensity of the voivodeship. It is important to take the large domestic firms since (large) foreign affiliates might have a contrary influence due to their typically little R&D spending in Poland (see section 2.2.3). In fact, taking the corresponding data of the 16 voivodeships over a period of four years (2004-2007) yields a positive and statistically significant correlation. Yet, far not all circumstances behind that relation are clarified. What remains unanswered is, for instance, whether Poland shows negative correlations between the size of a firm and its R&D intensity in certain high-tech sectors as it has been observed in other countries. Again, to answer these questions sufficiently, a full-scale analysis at the micro-/firm-level is indispensable. This might provide some deeper insights into the relationship between the firm size and the R&D activity of Polish firms (and also their absorptive capabilities).

In order to further empirically test the above described relations between the voivodeships’ R&D intensities on the one side and the shares of workers employed in the high-tech sectors as well as the shares of large domestic firms on the other side, we suggest the following regression model: the regional R&D intensities shall be the dependent variable that we seek to explain, whereas the share of workers employed in the high-tech sectors and the share of large domestic firms are the independent variables. The regression comprises and combines both time series data (2004-2007) as well as cross-sectional data (16 voivodeships). The results of this pooled regression model indeed shows a certain explanatory power as can be seen in the following

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38 Pearson correlation coefficient is .6; significant at .01 level.
39 The high-tech sectors comprise high-tech manufacturing as well as knowledge-intensive high-tech services.
40 All data are taken from the Eurostat database (i.e. the R&D intensities and the share of workers employed in the high-tech sectors) and from the regional databank of the Central Statistical Office of Poland (i.e. share of large domestic firms).
Table 4: Results of the Pooled Linear Regression

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Dependent variable</th>
<th>Constant (Standard error)</th>
<th>Share of high-tech (Standard error)</th>
<th>Share of large domestic firms (Standard error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D intensity</td>
<td></td>
<td>-.269*** (.046)</td>
<td>4.364*** (.714)</td>
<td>282.988*** (43.752)</td>
</tr>
</tbody>
</table>

*** significant at .001 level; adjusted r-squared: .6.

The figures show that an increase in the share of high-tech sectors in a certain voivodeship raises its R&D intensity, too. The same applies to the second independent variable, the share of large domestic firms. If it does rise, it also increases the regional R&D intensity. The results of this regression can partly explain and help to understand causes of the regional differences in Poland when it comes to R&D spending, or more concretely, to the R&D intensities of the Polish voivodeships.

3 Conclusion

The findings presented in this paper showed the substantial impacts that diverse aspects of the economy’s structure have on the R&D landscape in the Polish enterprise sector. All three aspects in focus appear to have a more or less significant influence on the aggregate Polish business R&D. First of all, the country’s economic base is mainly and stronger than others characterised by low and medium-low technology production and less knowledge-intensive services. These economic sectors typically – regardless of the country in focus – involve relatively little R&D activities due to their products’ and services’ specificities. As a result of that, they do not or hardly encourage aggregate business R&D. The relatively high – compared to other industrial sectors – value added of low-tech sectors and, simultaneously, the relatively lower importance of the most R&D-intensive sectors in Poland can explain one part of the low Polish business R&D. However, it does not help to understand the extraordinary low R&D intensities of Poland’s high and medium-high-tech sectors in comparison to those of other industrialised countries. Though the respective data about foreign-controlled companies in Poland were only available for the year 2007, they seem to further shed some light on the R&D performance of some sectors. The prevalent activities of foreign affiliates, above all,
in typical R&D-intensive sectors such as electrical and optical equipment, chemicals and chemical products, and motor vehicles, trailers, and semi-trailers is likely to lower aggregate R&D intensities. This is because MNCs tend to conduct high value activities such as R&D in their home countries or in other highly industrialised countries. Moreover, the findings indicate that from a macro perspective and without regarding the different economic activities, large Polish (domestic) firms spend relatively more on R&D than smaller ones. Both at the national as well as at the regional level the results seem to support this.

To sum it up, in this paper we suggest taking into account the structure of the Polish economy more when discussing its low R&D performance. Further and deeper-reaching analyses might reveal more factors and details that are of essential importance for both the research and innovation policy in Poland and for its counterpart at the European level (including the adjustment of the European Structural Funds in Poland and other member states). We showed in the paper that the question whether Poland can reach the 3 percent target or not is largely connected to the country’s performance when it comes to the development of own domestic industries which are R&D-intensive. Hence, one can understand Polish officials when they question the merit of this target and point at their country’s disadvantages in this regard.

However, there are also other factors that help to understand the poor R&D performance: the market structure that does not require R&D (yet), the country’s competitive advantage that heavily relies on other determinants or the attitude of the population and of entrepreneurs towards innovation in general. With the further growing integration into both the European market as well as the global markets on the one side and the increasing factor prices on the other side, at least some of these circumstances are likely to change. One strategy to tackle current and upcoming challenges in this context might be to focus on improving the absorptive capabilities of Polish enterprises. Finally, another aspect is often missing in the discussion. Innovation should not be reduced to R&D; especially innovation in services often does not involve R&D, but anyway contributes largely to create added value.41 Regardless of Poland’s success in developing domestic industrial enterprises with high knowledge-intensity, policy makers should have in mind this aspect, too.

4 Bibliography


**Online Databases:**

Central Statistical Office of Poland (GUS):

Statistical Office of the European Communities (EuroStat):

Statistical Databases of the Organization for Economic Cooperation and Development (OECD.Stat):
http://oberon.sourceoecd.org/vl=2583803/cl=44/nw=1/rpsv/dotstat.htm (Last Access Date: 11/08/2010).
5 Appendix

Appendix 1: R&D intensity and GVA shares of the manufacturing sectors in Germany (2006), in percent

Source: Author’s illustration; OECD database.

Appendix 2: R&D intensity and GVA shares of the manufacturing sectors in the Czech Republic (2006), in percent

Source: Author’s illustration; OECD database.
Appendix 3: R&D intensity and GVA shares of the manufacturing sectors in Hungary (2006), in percent

![Graph showing R&D intensity and GVA shares of the manufacturing sectors in Hungary (2006).](image)

Source: Author’s illustration; OECD database.

Appendix 4: R&D intensities by economic activity in selected European countries (2006), in percent

<table>
<thead>
<tr>
<th>Economic Activity</th>
<th>Czech Republic</th>
<th>Germany</th>
<th>Hungary</th>
<th>Poland</th>
<th>Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals and chemical products</td>
<td>12.49%</td>
<td>14.20%</td>
<td>11.70%</td>
<td>2.11%</td>
<td>17.07%</td>
</tr>
<tr>
<td>Machinery and equipment, n.e.c.</td>
<td>3.07%</td>
<td>5.70%</td>
<td>1.24%</td>
<td>0.99%</td>
<td>11.16%</td>
</tr>
<tr>
<td>Electrical and optical equipment</td>
<td>3.95%</td>
<td>11.16%</td>
<td>1.58%</td>
<td>1.34%</td>
<td>35.24%</td>
</tr>
<tr>
<td>Motor vehicles, trailers, and semi-trailers</td>
<td>7.45%</td>
<td>17.27%</td>
<td>1.14%</td>
<td>1.35%</td>
<td>28.40%</td>
</tr>
<tr>
<td>Other transport equipment</td>
<td>14.73%</td>
<td>22.04%</td>
<td>0.10%</td>
<td>3.38%</td>
<td>21.82%</td>
</tr>
<tr>
<td>Transport, Storage, and Communications</td>
<td>0.14%</td>
<td>0.24%</td>
<td>0.04%</td>
<td>0.12%</td>
<td>1.62%</td>
</tr>
<tr>
<td>Computer and related activities</td>
<td>5.41%</td>
<td>5.02%</td>
<td>1.20%</td>
<td>1.22%</td>
<td>6.32%</td>
</tr>
<tr>
<td>Research and development</td>
<td>34.85%</td>
<td>15.20%</td>
<td>1.78%</td>
<td>5.60%</td>
<td>no data</td>
</tr>
<tr>
<td>Other business activities</td>
<td>0.62%</td>
<td>0.30%</td>
<td>0.20%</td>
<td>0.02%</td>
<td>0.23%</td>
</tr>
</tbody>
</table>

Source: OECD database.