Chapter 5
The Development of Qualification and Employment Structures in Non-R&D-Intensive Industry Sectors–The Case of Germany

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Abstract In the course of changes within the economic structure in many modern economies, there has been a trend towards more knowledge-, research- and innovation-intensive sectors. These changes were very much in favour of highly skilled employees, while the share of employment of less qualified personnel has decreased. Within this chapter, we aim to provide empirical evidence for the structural changes in the German economy that have occurred since the mid-1990s and try to shed some light on the current and future demand for highly qualified labour, especially in non-R&D-intensive sectors.

With the help of data from the German *Microcensus*, we performed a structural decomposition ("shift-share analysis") of the employment changes among highly skilled workers in Germany.

Although there has been a shift in employment towards the service sectors over the years, 22 % of the German workforce remains in the manufacturing sectors, with the majority of people being employed within non-R&D-intensive parts of the industry. Employment in non-R&D-intensive manufacturing industries has slightly decreased over the years, while there has been increasing demand for highly qualified personnel, which is especially true for university graduates. The non-R&D-intensive sector is increasingly dependent on highly skilled workers to maintain or even increase its innovative potential, which is critical with regard to its competitiveness.

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5.1 Introduction

Within economic innovation research, the ability to innovate has long been considered a key factor in long-term competitive advantage. However, this ability to innovate, or innovative capacity, cannot be considered separately from the people who perform innovative activities in the form of new or improved products or processes and thereby contribute to the development of new markets, increased market share or cost reduction.

Innovation is, first of all, the transfer of ideas to products, services or processes. The generation of ideas, as well as the transfer of these ideas to the market, are mainly driven by knowledge and creativity. Codified knowledge is one aspect of knowledge that surely plays an important role: "know-what" is the foundation. However, tacit knowledge—or, in other words, "know-how"—is at least as important as codified knowledge (Berg Jensen et al. 2007; Foray 1997; Foray 2004; Nonaka and Takeuchi 1995; Tödtling et al. 2009). In fact, tacit knowledge only exists in the brains of people, and it is difficult or even impossible to codify.

In addition to knowledge creation and dissemination itself, another important factor is the complexity of current products, processes and services. Of particular importance is the necessary division of labour and tasks that accompany this complexity (Frietsch and Grupp 2007). This division of labour makes economic activity more efficient because, due to specialisation, it is not only possible to use more in-depth knowledge in certain areas but also to benefit from scale effects in the use of knowledge. All of these aspects make people, their knowledge and their skills among the most important—if not the most important—resource in modern economies.

The economic structure has changed in the past, and there has been a trend towards more knowledge-, research- and innovation-intensive sectors in many modern economies (Frietsch 2011; Frietsch and Gehrke 2006; Hanushek and Wößmann 2007). This trend can be perceived as a between-sectors effect: in innovation-oriented economies, the share of sectors with high price competition and low qualification structures has decreased, while the share of innovation-oriented and quality competition-based sectors has increased. In addition, the literature has also revealed that within the sectors, a trend towards higher qualifications has been visible, i.e., there has been a shift on the demand side, implying that a structural change has occurred in the sectors themselves. At the same time, the supply of highly qualified personnel has also increased in recent decades in most of the industrialised countries, which has made these structural changes possible.

All of these changes have been summarised using the term "skill-biased technological change," which has been and remains the subject of many analyses and both empirical and theoretical work (Card and DiNardo 2002; Greiner et al. 2004; Machin 2001; Machin 2003). This term implies that the technological changes of the past (and also the present) were very much in favour of highly skilled employees, while the share of employment of less qualified personnel has decreased.

In this context, human capital, i.e., people's educations and skills, has thus played a key role because human capital equipment can be regarded as a basic factor of productivity. Therefore, analysis of the present and future endowments of these factors remains a very important task for innovation research. This is true not only for high-technology areas but also for non-R&D-intensive sectors. A potential future shortage of well-trained and qualified staff could be seen as a barrier to R&D projects and thus to overall economic development (Leszczensky et al. 2010; OECD 2011; OECD 2012).

This chapter seeks to provide empirical evidence for the structural changes in the German economy that have occurred since the mid-1990s. Moreover, it also attempts to shed some light on the demand for highly qualified labour, especially in non-R&D-intensive sectors rather than the high-tech areas that are most often the scope of such types of analyses and discussions. The chapter addresses two basic questions. First, we examine what type of formal qualifications are needed in non-R&D-intensive industries in Germany, and how the demand for personnel has evolved over the last decade, allowing us to estimate future developments. Second, in this context, it is highly relevant to assess the demand for especially highly skilled workers in non-R&D-intensive sectors because such an assessment could lead to important conclusions for both the educational system and the labour market.

To answer these questions, the sections of this chapter first provide an overview of the data and classifications used for our analyses. Next, we offer some descriptive statistics on the employment trends in German industry, followed by a shift-share analysis, which disentangles the different structural trends and facilitates an understanding of the contributions and effects of overall economic trends relative to the structural changes within and between sectors. The final section concludes the chapter.

5.2 Data and Classifications

To analyse the qualification and employment structures, data from the German *Mikrozensus*, from the years 1996 to 2006, are employed.[1] The focus for our analyses is only on employed persons, as defined by the concept of employment used by the International Labour Organization (ILO) (Eurostat 1999; International Labour Office 1990; Schmidt 2000).[2] In addition, we look more deeply at employment only within the commercial economy, i.e., non-profit organisations and public

[1] The *Mikrozensus* constitutes the official representative statistics on population and the labour market in Germany. One percent of all German households participate in each wave of the survey. The selection of surveyed households is conducted using a single-stage stratified sample. In 2006, for instance, a total of 370,000 households and all related persons (820,000) were interviewed.

[2] According to the concept of the ILO, all persons between the ages of 15 to 64 are regarded as employed if they are working for at least one hour per week.

Table 5.1 R&D- and non-R&D-intensive sectors in the manufacturing industry (Source: NACE, Rev. 1.1, own compilation)

Name	NACE	Category
Manufacture of food products and beverages	15	Non-R&D-intensive
Manufacture of tobacco products	16	
Manufacture of textiles	17	
Manufacture of wearing apparel; dressing and dyeing of fur	18	
Tanning and dressing of leather; manufacture of luggage, handbags, etc.	19	
Manufacture of wood and of products of wood and cork, except for furniture	20	
Manufacture of pulp, paper and paper products	21	
Publishing, printing and reproduction of recorded media	22	
Manufacture of coke, refined petroleum products and nuclear fuel	23	
Manufacture of chemicals and chemical products	24	R&D-intensive
Manufacture of rubber and plastic products	25	Non-R&D-intensive
Manufacture of other non-metallic mineral products	26	
Manufacture of basic metals	27	
Manufacture of fabricated metal products, except for machinery and equipment	28	
Manufacture of machinery and equipment n.e.c.	29	R&D-intensive
Manufacture of office machinery and computers	30	
Manufacture of electrical machinery and apparatus n.e.c.	31	
Manufacture of radio, television and communication equipment and apparatus	32	
Manufacture of medical, precision and optical instruments, watches and clocks	33	
Manufacture of motor vehicles, trailers and semi-trailers	34	
Manufacture of other transport equipment	35	
Manufacture of furniture; manufacturing n.e.c.	36	Non-R&D-intensive
Recycling	37	

administrations are excluded. Finally, we focus on the manufacturing sector within our analyses and differentiate between R&D- and non-R&D-intensive industries. Nevertheless, in the course of the analyses, we compare our figures to total employment, as well as to employment within the service sector. The non-R&D-intensive sectors are defined according to their R&D and knowledge intensities, as defined by Legler and Frietsch (2007), using 2-digit NACE (Rev. 1.1) codes. An overview of the analysed industries, as well as their categorisations according to their R&D intensity, can be found in Table 5.1.

5.3 Qualification and Employment Structures

Within this section, we first provide an overview of the general structures of qualification and employment in the German economy to obtain an impression of the size of the relevant sectors, as well as their demand for especially highly skilled personnel.

Starting with employment, Fig. 5.1 shows that approximately 23 % percent of the German workforce is employed within the non-commercial economy, i.e., public administration or non-profit organisations. Consequently, 77 % of all employees are located within the commercial economy, which is the focus of the subsequent analyses. In 2006, 68 % of all of the employees within the commercial economy belonged to the service sector. This percentage has increased continuously over the years. However, this increase has resulted in a slight decrease in the proportion of employees in the manufacturing sector over the years. In 2006, approximately 22 % of the German workforce was located within the manufacturing sector or in traditional industries. Within the manufacturing sector, 58 % of employment can be attributed to non-R&D-intensive areas, which corresponds to a share of 13 % of the total German workforce. The R&D-intensive areas, on the other hand, employed approximately 9 % of the total German workforce (42 % of employment within the manufacturing sector). Over the years, employment in the non-R&D-intensive manufacturing industries has slightly decreased, while the proportion in R&D-intensive sectors has increased.

As previously stated in the introduction, it is important to assess the demand for highly skilled workers within non-research-intensive sectors because such an assessment could lead to important conclusions for the educational system, as well as for the labour market. Figure 5.2 therefore provides us with a first impression of the sectoral qualification structures within the German economy. Because we focus on highly skilled personnel, as well as university graduates (as a subgroup of highly skilled employees[3]), both groups are reported separately in this graph. University graduates include all persons who hold a university degree or PhD.

The data show that the proportion of highly skilled employees within the total workforce ranged from 23 % in 1996 to 25 % in 2006. With regard to university graduates, this proportion ranged from 14 % to 16 %, with slight growth over the entire observation period. The largest proportion of highly skilled personnel in Germany can be found in the non-commercial sector (36 %). In the service sector, the proportions of highly skilled personnel and graduates were greater than average, at approximately 27 % and 18 %, respectively, while a less than average share of highly skilled employees was engaged in the manufacturing sector. However, this proportion can be attributed mostly to the non-R&D-intensive manufacturing sectors, in which the share of highly skilled personnel was clearly less than average, with a value of approximately 16 %. The percentage of highly skilled employees in R&D-intensive sectors, in contrast, was greater than average, reaching 27 %.

[3] In addition to university graduates, individuals who have acquired a degree at a technical school belong to the group of highly skilled employees.

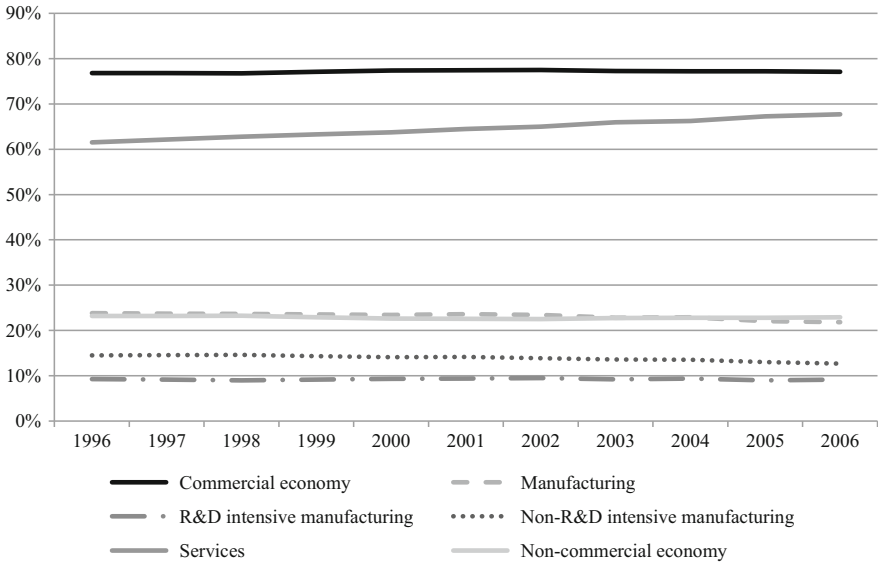

Fig. 5.1 Shares of employees by sectors, 1996–2006 (Source: German Mikrozensus 1996–2006, own calculations)

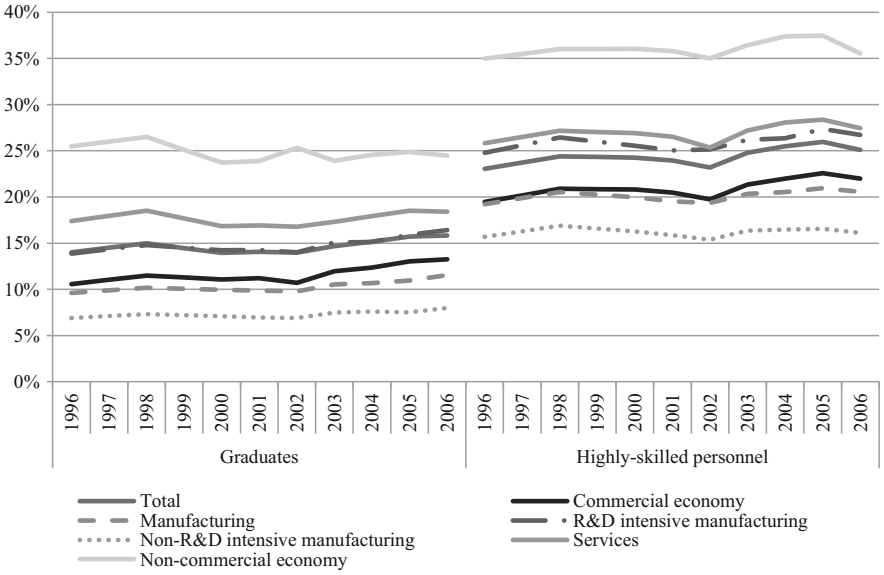

Fig. 5.2 Proportions of academics and highly skilled personnel among total employees, 1996–2006 (Source: German Mikrozensus 1996–2006, own calculations)

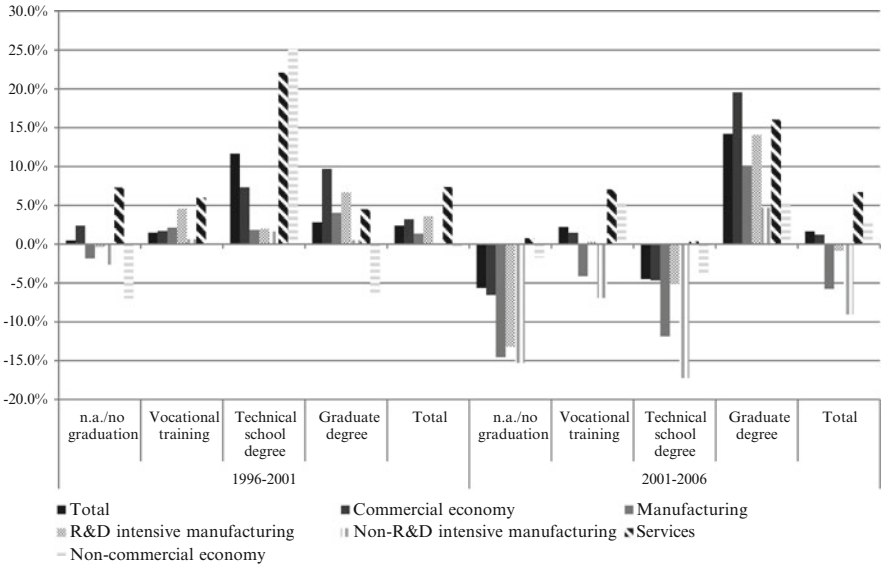

Fig. 5.3 Percentage changes in the employment structure by educational attainment between 1996 and 2001 and 2001 and 2006 (Source: German Mikrozensus 1996–2006, own calculations)

To draw a complete picture of the qualifications required across sectors, the changes in the employment structure by educational attainment over two time periods (1996–2001 and 2001–2006) are depicted in Fig. 5.3.

In particular, employment in the service sector has grown over the years. Between 1996 and 2001, the additional labour demand within this sector was mostly focused on employees with technical school degrees. Between 2001 and 2006, however, the demand for graduates rose within the service sector. With regard to manufacturing, we can also observe additional demand for labour between 1996 and 2001, especially in the case of academics. However, this growth can mostly be attributed to the R&D-intensive manufacturing sector. The demand for labour in the non-R&D-intensive sectors stagnated during this time period. For the period between 2001 and 2006, a slightly decreasing demand for labour within the manufacturing sector can be observed because the demand for employees with technical school degrees in particular decreased in the non-R&D-intensive manufacturing sectors. However, the demand for employees with university degrees increased in these industries.

5.4 Structural Decomposition—Shift-Share Analysis

To qualify these findings and further analyse the changes in the employment structure, especially for highly skilled personnel, this section performs a structural decomposition of the employment changes among highly skilled workers through a Shift-Share Analysis. Shift-Share Analysis allows for decomposition of the growth

rates between two points of time. Specifically, the overall change within the sectors is divided into three components, namely: a) the general *trend effect*, b) the *structural effect* and c) what is called the *intensification effect* (see, for example, Casler 1989; Dinc and Haynes 1999; Gehrke and Legler 2007; Leszczensky et al. 2009; Ray and Harvey 1995; Stevens and Moore 1980).

The trend effect reflects the change in the demand for highly skilled personnel between two points in time, which can be attributed to the general change in employment within the German economy as a whole. In other words, the trend effect encompasses the growth that one would expect if the proportion of highly skilled workers developed in parallel to the changes in total employment, given a constant sectoral structure and a constant demand for specific human capital. The structural (or inter-sectoral) effect isolates the proportion of the change in the demand for highly qualified personnel that is caused by the structural changes in a given sector. If employment increases (or decreases) within a given sector, then the share of highly qualified personnel employed within this sector also increases (decreases). This effect thus provides evidence of changing trends in the development of sectoral employment structures, as well as information about specific qualification requirements. The intensification (or intra-sectoral) effect, in contrast, reflects the change in the demand for highly skilled personnel, based on the actual sector-specific need for these skills. This indicator becomes positive when a sector, independent of the general trend or structures within the economy, demands more highly skilled personnel. In other words, the specific requirements for given skill levels within a given sector grow.

The formulae used for the calculation of the three effects are as follows:

$$\mathrm{Trend}_{es}^{t} = \mathrm{HQ}_{es}^{t-1} * \left(\frac{\mathrm{HQ}_{e}^{t}}{\mathrm{HQ}_{e}^{t-1}} - 1 \right)$$

$$\mathrm{Structure}_{es}^{t} = \mathrm{HQ}_{es}^{t-1} * \left[\left(\frac{\mathrm{HQ}_{es}^{t}}{\mathrm{HQ}_{es}^{t-1}} \right) - \left(\frac{\mathrm{HQ}_{e}^{t}}{\mathrm{HQ}_{e}^{t-1}} \right) \right]$$

$$\mathrm{Intens}_{es}^{t} = \mathrm{HQ}_{es}^{t-1} * \left[\left(\frac{\mathrm{HQ}_{es}^{t}}{\mathrm{HQ}_{es}^{t-1}} - \frac{\mathrm{HQ}_{es}^{t}}{\mathrm{HQ}_{es}^{t-1}} \right) \right]$$

$$\mathrm{Total}_{es}^{t} = \mathrm{Trend}_{es}^{t} + \mathrm{Structure}_{es}^{t} + \mathrm{Intens}_{es}^{t}$$

where HQ = Highly-qualified personnel, e = Employees, s = Sector and t = Time.

In summary, for further discussion of the results, it is important to note that

- the trend effect reflects the general change in employment within the German economy;
- the structural effect reflects the role of the change in sectors; and
- the intensification effect reflects the changes in the demand for highly skilled personnel within a given sector.

The results of the structural decomposition of the changes in the employment structure from 1996 to 2001 and 2001 to 2006 can be found in Table 5.2. Concerning the first period, we observe a total growth of 6.27 % in the employment of highly

Table 5.2 Percentage change in the employment of highly skilled personnel by components (Source: German Mikrozensus 1996–2006, own calculations)

	Percentage change (1996–2001)				Percentage change (2001–2006)			
Sector	Total	Trend effect	Structural effect	Intensification effect	Total	Trend effect	Structural effect	Intensification effect
Total	6.27	2.38	−0.42	4.31	6.52	1.65	0.21	4.66
Commercial economy	8.60	2.38	0.81	5.41	8.59	1.65	−0.43	7.37
Manufacturing	2.93	2.38	−1.01	1.56	−0.75	1.65	−7.42	5.02
R&D-intensive manufacturing	4.59	2.38	1.11	1.09	3.79	1.65	−4.24	6.38
Non-R&D-intensive manufacturing	0.46	2.38	−2.86	0.93	−7.83	1.65	−10.28	0.80
Services	10.27	2.38	4.99	2.90	10.39	1.65	5.07	3.67
Non-commercial economy	1.98	2.38	−2.68	2.28	2.45	1.65	1.47	−0.67

skilled personnel within the German economy, of which 2.38 % can be attributed to the trend effect. With regard to the structural effect, we find a negative value in total; however, this result must be interpreted in light of the trend effect, i.e., a positive sign indicates that a given sector has grown more rapidly than the economy as a whole, whereas a negative sign indicates slower growth. Thus, positive values reflect increasing demand for highly skilled personnel within a given sector.

A highly positive value, even exceeding the trend effect, can be found in the service sector. However, the R&D-intensive manufacturing sector also shows a positive indicator, which suggests that this sector has grown compared to others. The value for the non-R&D-intensive sectors has a negative sign, indicating a relative decline in the sector. However, the intensification effect, or the intra-sectoral effect, is positive for the non-R&D-intensive industries during this time period. The intensification effect is also the most interesting indicator because it allows for inferences beyond the general trend and structural effects about the demand for highly qualified labour within the respective sectors. Despite the structural changes within the non-R&D-intensive sectors, which cause the demand for highly qualified personnel to decrease, we can nevertheless state that the actual sector-specific demand for highly qualified labour increased between 1996 and 2001.

A similar picture can be drawn for the period between 2001 and 2006. Nevertheless, we identified total growth in the demand for highly skilled personnel. The trend effect was smaller than during the previous time period, whereas the structural effect showed more extreme negative values, especially in the manufacturing sector. However, the intensification effect was more positive in manufacturing. Thus, although inter-sectoral shifts in the demand for highly qualified labour between the sectors could be observed, e.g., between manufacturing and services, the sector-specific demand for highly qualified labour increased within manufacturing. This change was especially prominent in the R&D-intensive manufacturing sectors. However, the non-R&D-intensive sectors also showed increased demand for highly qualified labour, beyond the general trend.

In summary, we can state that although we observe a major structural shift in the demand for highly qualified personnel from the manufacturing to the service sectors, both the R&D- and non-R&D-intensive sectors showed intensified demand for highly qualified personnel.

Conclusions

In this chapter, we have provided an overview of the qualification structures and employment trends in non-R&D-intensive business sectors in Germany. Because human capital equipment can be regarded as a basic factor of productivity, it is important to know which types of formal classifications are needed in German non-R&D-intensive industries, especially in the case of highly qualified personnel with regard to innovative activities.

The results of the analyses showed that, although there has been a shift in employment towards the service sectors, approximately 22 % of the German

(continued)

workforce remains in the manufacturing sector or traditional industries. The majority of this 22 % is employed within non-R&D-intensive manufacturing sectors. However, employment in non-R&D-intensive manufacturing industries has slightly decreased over the years, while the proportion of employment in R&D-intensive sectors has increased. Furthermore, there has been increasing demand for highly qualified personnel in non-R&D-intensive sectors, although this demand has been lower than in R&D-intensive industries. Thus, it is interesting to note that the demand for university graduates in particular has increased, whereas the demand for employees with technical school degrees has decreased.

When decomposing the change in the employment of highly skilled personnel into three components, it becomes obvious that although there was a structural shift in the demand for highly qualified personnel from the manufacturing sector to the service sector, both the R&D- and non-R&D-intensive sectors showed increased demand for highly qualified personnel over time. This outcome leads to the conclusion that the non-R&D-intensive sector is increasingly dependent on highly skilled workers to maintain or even increase its innovative potential, which is critical with regard to its competitiveness.

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