

University of Economics, Prague

Faculty of Informatics and Statistics

Department of Economic Statistics

**Preparation of Changes in the Educational System
Resulting from Industry 4.0 Program**



Authors:

doc. Ing. Jakub Fischer, Ph.D.

Ing. Petr Mazouch, Ph.D.

Prague, September 2017

Executive Summary

The objective of this study is to analyze the development of secondary vocational education in individual fields in relation to employment trends in the relevant industries and in the context of national initiative Industry 4.0 (*Průmysl 4.0*). Between 2009 and 2016, a marked change occurred in the Czech Republic in the industry structure, consisting in the strengthening of the manufacturing industry, in particular in sectors within the automotive industry. The change in the structure of added value was more prominent than the employment structure.

Secondary vocational education exhibited a significant downturn in 2009-2016, the number of graduates in that period declined by 38.5%. In certain industries, this does not correspond to employment trends and, by extension, to labor market requirements, and moreover, a significant decline occurred in Electrical Engineering, Communications, IT and Mechanical Engineering, Manufacturing, which are important precisely from the perspective of the Industry 4.0 initiative. In our opinion, secondary vocational education therefore requires a certain intervention so as to prevent a further paralysis of economic development in future periods due to labor shortage.

Work productivity increased by approx. 12% in 2009-2016 at constant prices, nevertheless, said growth was, surprisingly, slowed down by negative developments in the sectoral structure consisting of employment shifting towards sectors with lower work productivity.

Based on the age structure of teachers and general nurses, an analysis of trends in these areas of education, and in light of an increased future demand for health care and social services, we would like to point out the threat of a serious shortage of labor in these workforce categories.

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Introduction

According to the national initiative Industry 4.0 (*Průmysl 4.0*), issued in 2015 by the Ministry of Industry and Trade of the Czech Republic (MIT, 2015), the inadequate preparedness of the Czech educational system for new labor market requirements is one of the weaker aspects of our preparedness for the Fourth Industrial Revolution.

The objective of this study is to analyze developments in the structure of the educational system in 2009-2016 and to compare them with developments in the structure of the Czech economy. Emphasis is placed on developments in secondary vocational education (whether study in the relevant field is completed by obtaining a certificate of vocational education or an A level certificate), which tended to be neglected in hitherto analyses. And yet, secondary vocational education is the principal source of labor for industrial sectors in the Czech Republic, including that part of the labor force that attends Bachelor's or Master's programs at universities before entering the labor market. From this perspective, the total decline in the number of graduates of secondary vocational schools in 2009-2016 (Fig. 0.1) is alarming, and so is the decline in the share of graduates of secondary vocational schools in the total number of secondary school graduates (Tab. 0.1).

The analytical focus is placed primarily on two types of industries: on the one hand, on industries whose growing qualitative and quantitative requirements on labor stem from a high degree of, and presumably strongly dynamic, informatization and digitization, and on the other hand, on industries where labor is largely impossible to replace with machines (health care services, social services, education). With a view to the expected aging of the population, it can further be reasonably presumed that the demand for health care and social services, and thus for labor in these sectors, will grow significantly because health care and social services are primarily used by older age groups of the population.

In the first chapter, we will briefly introduce gross added value and employment developments in 2009-2016, including a sectoral structure of added value and employment.

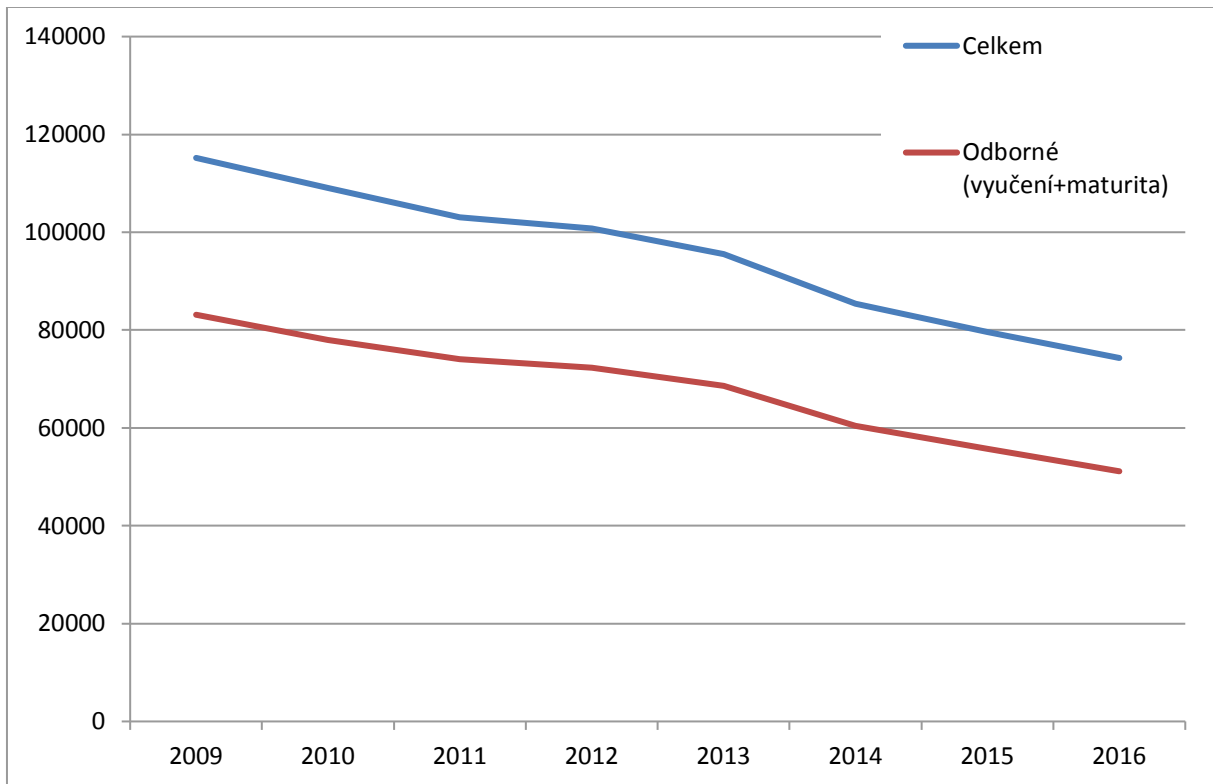
In the second chapter, we will compare added value developments in various sectors of the national economy to developments in the number of secondary vocational education graduates (broken down into graduates who obtained certificates of vocational education and graduates who obtained A level certificates), once again for 2009-2016, and will take a brief look at the structure of university graduates.

In the third chapter, we will focus on an analysis on work productivity developments as one of the basic building stones, as well as one of the monitored indicators of the Industry 4.0 initiative. We will first examine the issue of work productivity measurement where we will notice the relationship between the worker's work productivity and work productivity per hour worked. Further, we will follow the impact of changes in the structure of the Czech economy in 2009-201 using the index theory, specifically, by decomposing the variable composition index, as the change in overall work productivity stems not only from changes in work productivity within individual sectors, but also from changes in employment structure. As one of the objectives of the Industry 4.0 is to contribute to a change in the structure of the economy towards sectors with a higher added value, we will verify the hypothesis whether hitherto structural changes are indeed evolving in this direction or not.

The fourth chapter will be dedicated to areas necessary for the overall development of the society, i.e., health care services and education. We will monitor age structure of physicians and teachers in order to establish whether hitherto education in this area is sustainable in terms of attaining the necessary number of physicians and teaches in the upcoming period.

When referring to sectoral structure, we work, with a view to data availability, with a structure based on the Classification of economic activities (CZ-NACE), and on sub-sections of CZ-NACE in case of section C (Manufacturing) of the classification.

Fig. 0.1: Total number of secondary school graduates and secondary vocational school graduates (whether completed by obtaining a CVE or A level certificate) in the Czech Republic in 2009-2016



Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Tab. 0.1: Share of vocational education graduates in the total number of intramural study graduates, 2009-2016, Czech Republic

	2009	2010	2011	2012	2013	2014	2015	2016
Share of vocational education graduates	72%	72%	72%	72%	72%	71%	70%	69%

Source: Own table created using Ministry of Education Data, Statistical Yearbook of Education - performance indicators

1. Developments in gross added value and employment in the national economy of the Czech Republic in 2009-2016

In this chapter, we will compare developments in economic output, measured by developments in gross added value, and developments in the number of persons employed as a key indicator expressing involvement of labor as a factor of production.

Fig. 1.1 shows developments in gross added value in the Czech Republic in 2009-2016 at constant prices, i.e., stripped of price level developments measured by GDP deflator. Unlike in commonly used graphs, the individual sectors (according to CZ-NACE) are not arranged in alphabetical order by letters designating individual NACE sections, but are instead arranged in descending order according to the share of gross added value in the relevant sector in the total added value in 2016 (specifically, according to the share of gross added value at constant prices in case of Fig. 1.1, and the share of gross added value at current prices in case of Fig. 1.2).

Fig. 1.1 shows developments in the economic cycle, as recorded in 2009-2016. It shows a year-on-year economic downturn in 2012 and 2013, and, *a contrario*, a rather fast and stable growth starting from 2014.

Fig. 1.2 provides a more interesting picture: it shows developments in the structure of the economy in the relevant period. Unlike other transitional economies where the main focus of the national economy usually shifts from agriculture and industry to the service industry, the Czech Republic clearly exhibits an increase in the share of gross added value in manufacturing in 2009-2016. Such share of gross added value in manufacturing did not decline even during the period of an overall economic downturn (years 2012 and 2013), and, *a contrario*, grew significantly during years of economic growth (in particular in 2014). The share of manufacturing in added value of the national economy increased by six percentage points, to nearly 29%, in total. The Czech Republic is thus once again becoming a markedly industry-based economy.

Other important sectors include retail and wholesale trade, which is the second most important sector in terms of its added value share, and further, activities in the real estate sector and the non-market sector of public administration and defense and mandatory social security. It needs to be noted that in non-market sectors, gross added value traditionally consists, by definition, in particular of employee compensation (i.e., to simplify, of the volume of booked gross wages

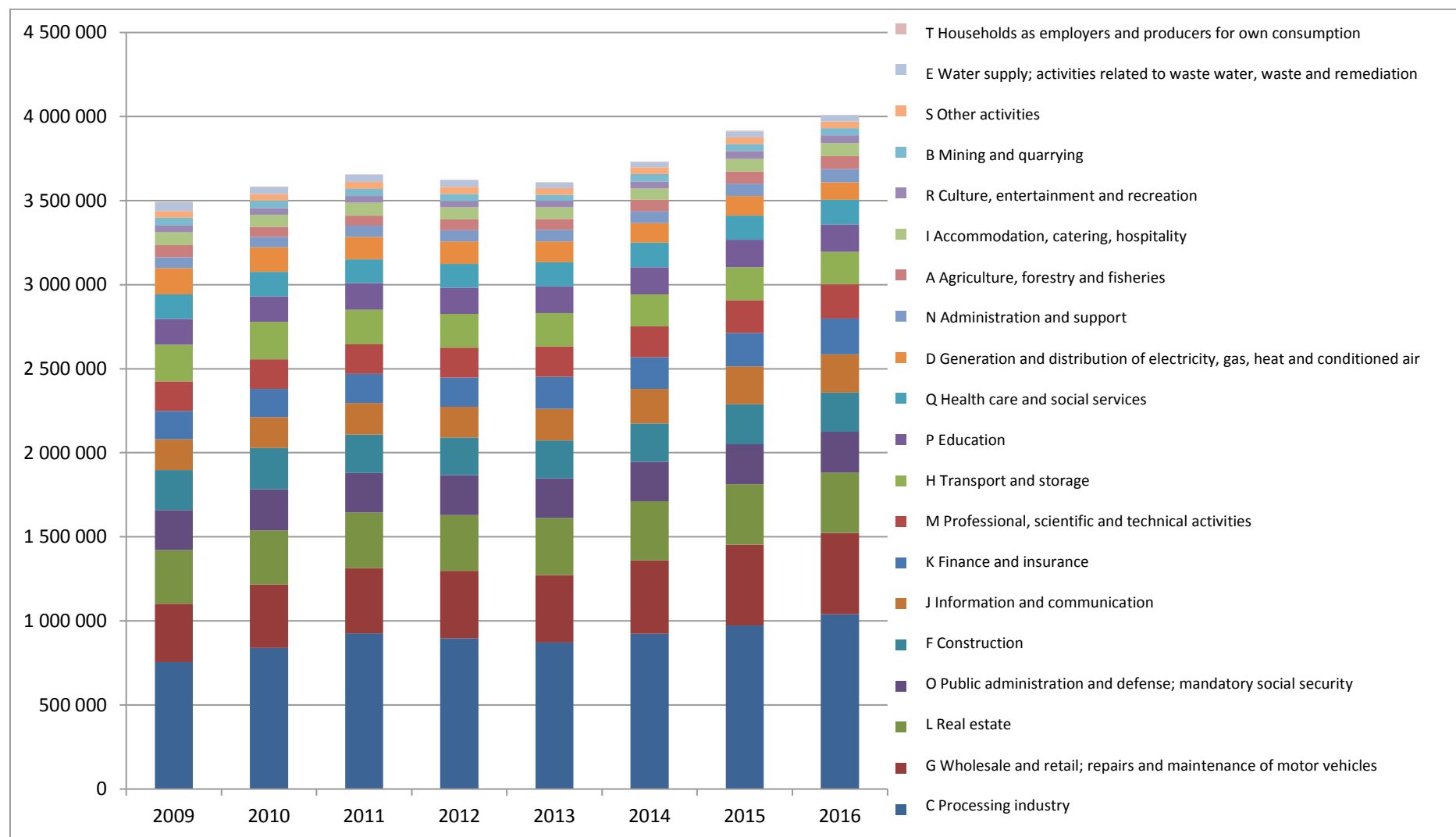
and salaries and mandatory payments made by employers towards health insurance and social security).

Fig. 1.3 and 1.4 document employment developments and the sectoral structure of employment, once again in 2009-2016. Note that employment developments, measured by the number of persons employed, does not directly follow the development of the output of the economy measured by gross added value. The development of the number of persons employed responds to economic development with a certain delay, because first of all, as in the economic policy at state level, various types of delays occur on the part of employers (cognitive, decision-making, implementation), and secondly, the economic cycle evolution is reflected to a greater extent in the number of hours worked, since in the economic downturn phase, the number of hours worked by current employees is reduced first (either by reducing overtime or, for instance, by increased incapacity for work), with lay-offs of redundant employees following later on. Similarly, in the expansion phase, existing employees are "utilized" first (for example, by increasing overtime), and only subsequently new employees are successfully recruited. As regards overall employment developments (Fig. 1.3), we can therefore observe year-on-year declines in the number of persons employed in 2010 and 2011 (as a result of the Great Recession of 2009), and, *a contrario*, markedly growing numbers of persons employed in 2015 and 2016 (while gross added value has started growing significantly on a year-on-year basis in 2014 already).

We will immediately notice differences in the development of the gross added value structure (Fig. 1.2) and the development of the employment structure. While the share of the industry in gross added value grew significantly (by nearly 6 pp, as already mentioned above), the increase in the share of the industry in employment was not nearly so substantial (it increased from approx. 26% to 28%). The increase in work productivity in the manufacturing sector is immediately obvious (or rather, a faster growth of work productivity in comparison with other industries). The structural employment graph (Fig. 1.4) is ranked according to the shares of individual sectors in total employment, and we can thus compare the importance of individual sectors in terms of value added on the one hand, and employment on the other hand. Note for instance that, from the perspective of added value, construction is only in the 5th or 6th place (depending on whether we express its share at current or constant prices), while from the employment point of view, it is the third most important sector after the manufacturing and trade sectors. The difference is obvious in particular given the fact that employment is expressed here in terms of the number of persons employed, rather than the number of hours worked,

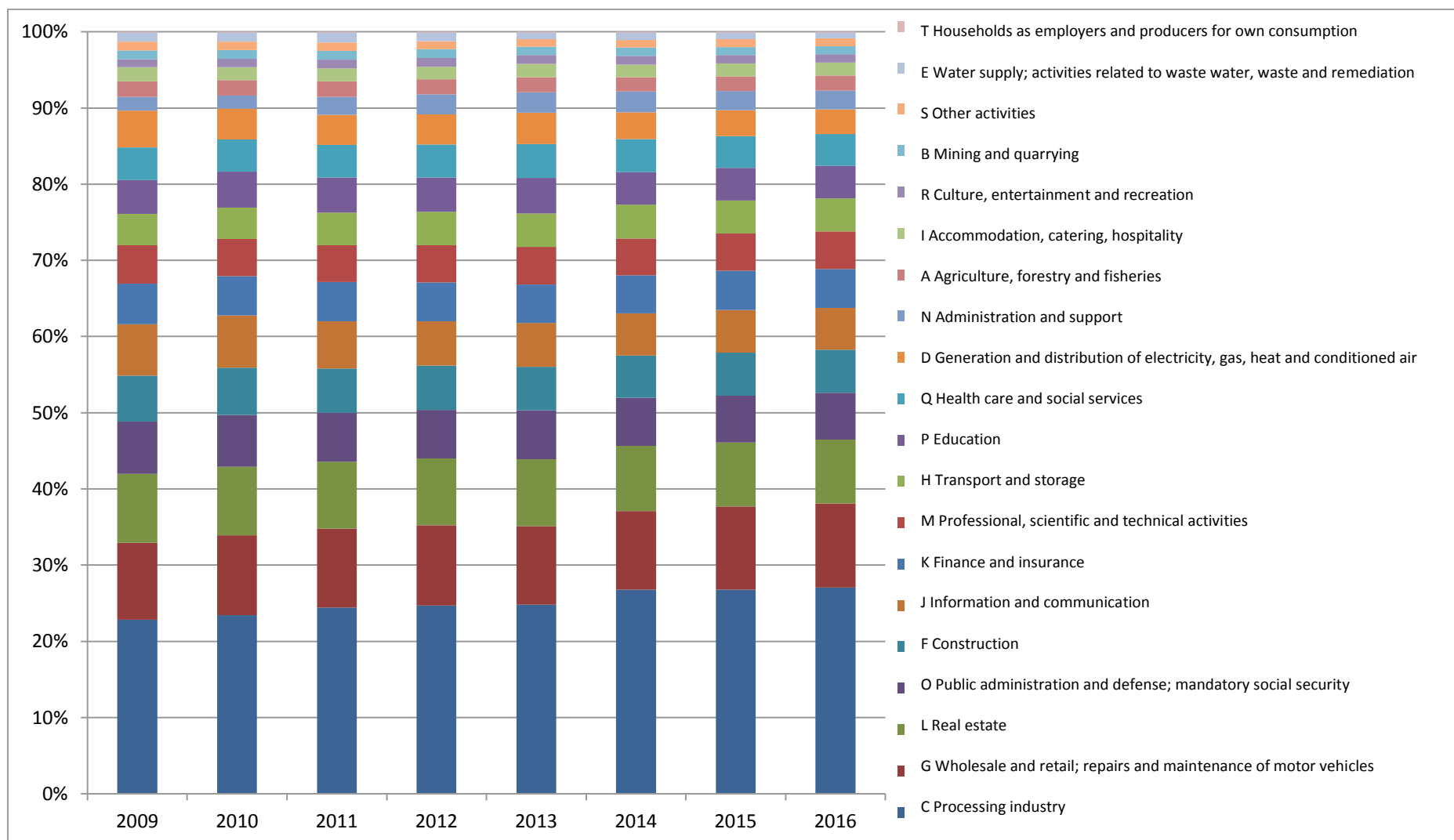
where the importance of the construction industry would be even greater (with a view to the average number of hours worked per person employed).

Fig. 1.1: Gross added value volume (at constant prices) of the national economy in the Czech Republic in 2009-2016 (CZK million)



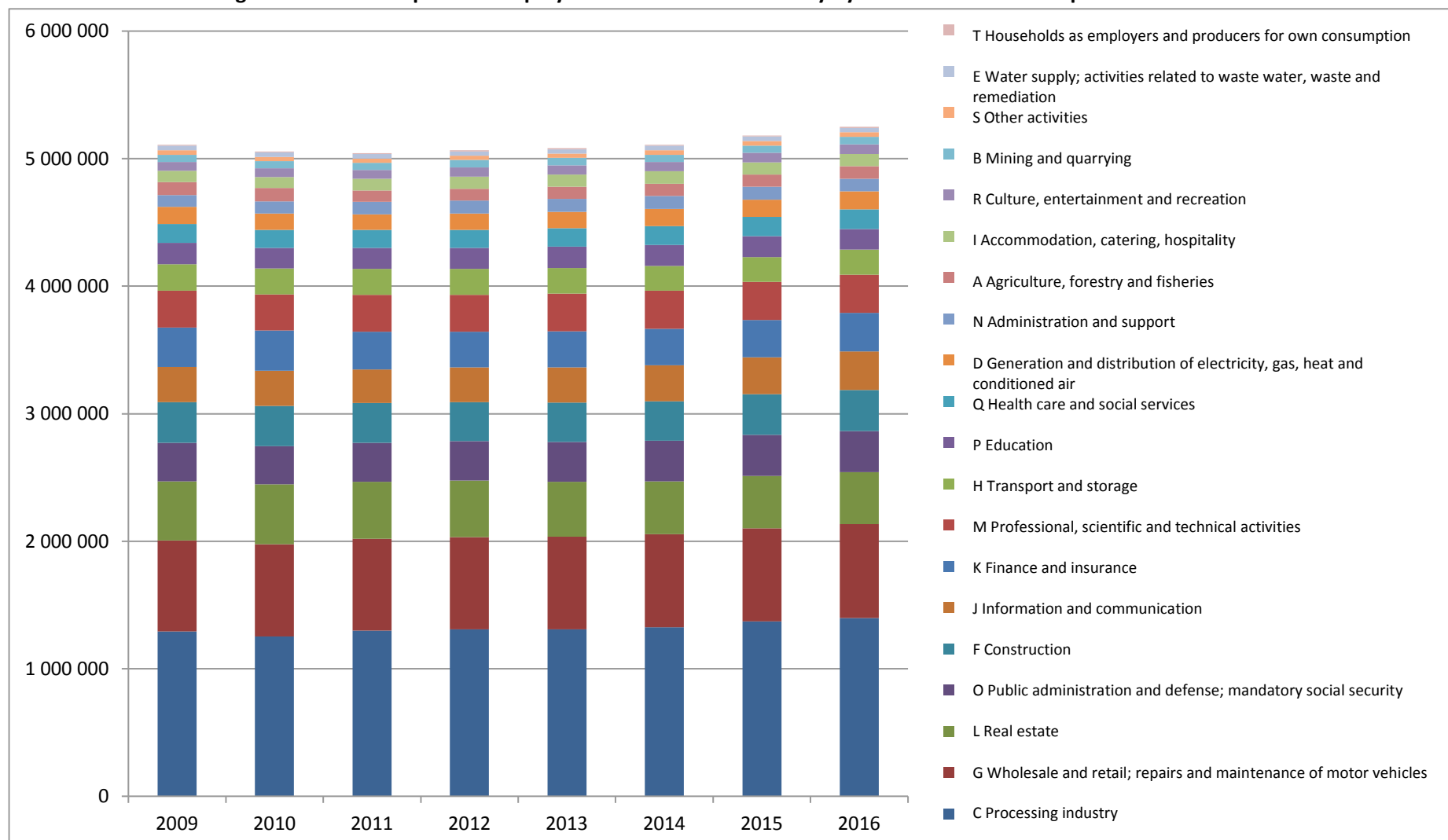
Source: Own figure created using Czech Bureau of Statistics data, GDP, national accounts - National Accounts Database

Fig. 1.2: Gross added value structure (at current prices) of the national economy in the Czech Republic in 2009-2016



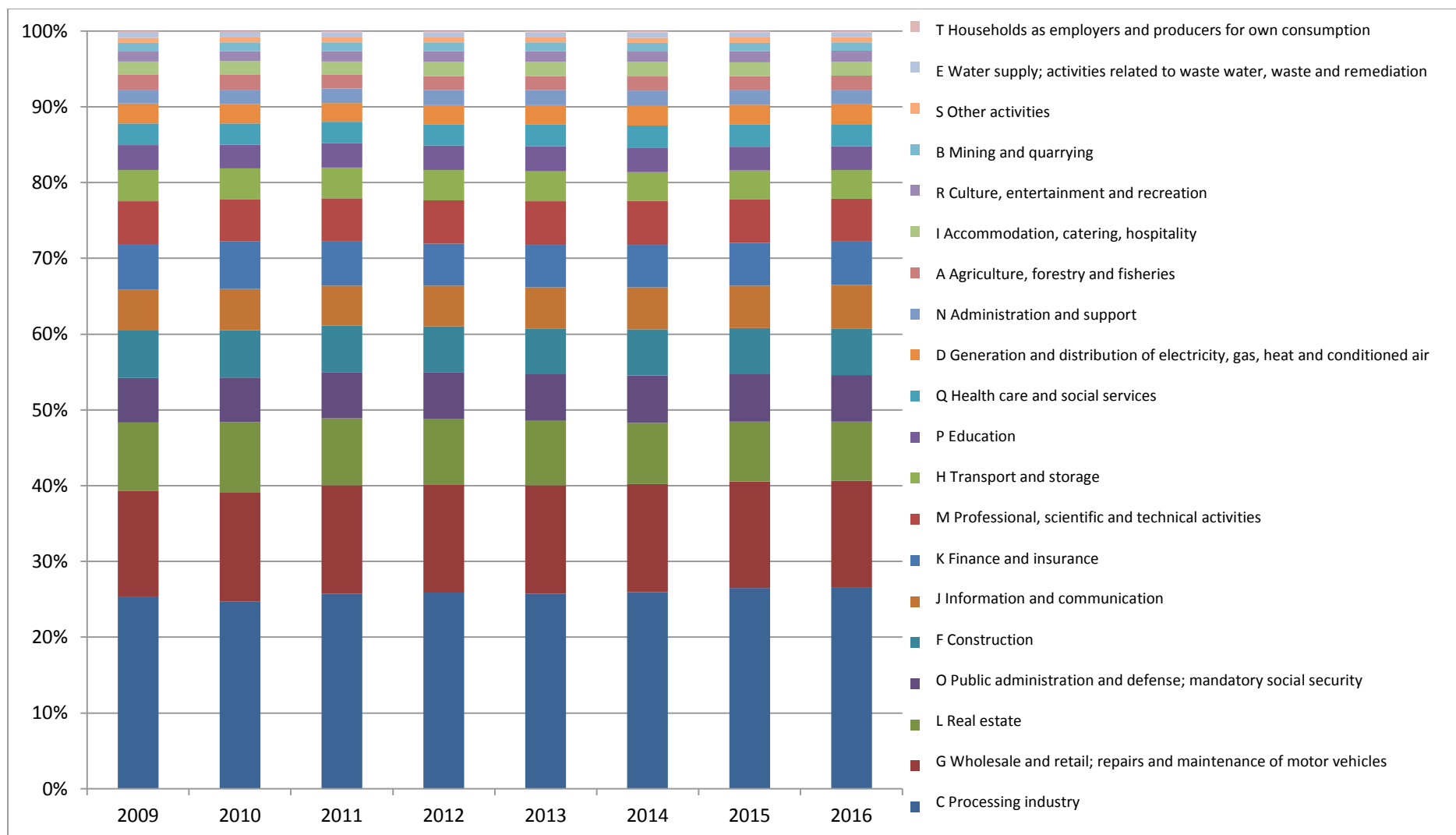
Source: Own figure created using Czech Bureau of Statistics data, GDP, national accounts - National Accounts Database

Fig. 1.3: Number of persons employed in the national economy by sector in the Czech Republic in 2009-2016



Source: Own figure created using Czech Bureau of Statistics data, GDP, national accounts - National Accounts Database

Fig. 1.4: Structure of persons employed in the national economy by sector in the Czech Republic in 2009-2016



Source: Own figure created using Czech Bureau of Statistics data, GDP, national accounts - National Accounts Database

Fig. 1.1 to 1.4 and the above comments show the importance of the manufacturing sector both for the gross added value of the Czech Republic and for employment. Therefore, let us look at this sector in more detail using the subsections of the CZ-NACE sectoral classification.

Fig. 1.5 shows the evolution of gross added value in 2009-2016 at constant prices in the individual segments of the manufacturing industry; it in fact provides a decomposition of the blue data series presented in Fig. 1.1. The sectors in Fig. 1.5 are ranked by their shares in the total gross added value of the manufacturing industry at constant prices in 2016. Fig. 1.6 then shows developments in the structure of the manufacturing industry based on its share in added value (at current prices).

The most important sector of the manufacturing industry is the *Manufacture of motor vehicles (save for motorcycles), trailers and semi-trailers*, whose share in the total added value of the manufacturing industry has been growing since 2009 and exceeded 20% in 2016. We note that the other four leading sectors are relatively closely linked to the manufacture of motor vehicles, be they manufacture of metal constructions and metal products, manufacture of machinery and equipment not referred to elsewhere, production of electrical equipment or production of rubber and plastic products. Nearly 60% of the total added value of the manufacturing industry in 2015 was created in these five most important sectors. A more detailed mutual relationship between the individual sectors and the strength of their ties to the manufacture of motor vehicles could be analyzed using input-output tables and input-output analysis, which, however, would significantly exceed the scope and focus of our study.

In Fig. 1.5, we note the procyclic development of the motor vehicle manufacturing sector where the development of gross added value in this sector followed the development of gross added value across the entire manufacturing industry. In light of the above-mentioned importance of the motor vehicle manufacturing sector not only for the manufacturing industry but also for the economy as a whole, this is not entirely risk-free for the future development of the national economy.

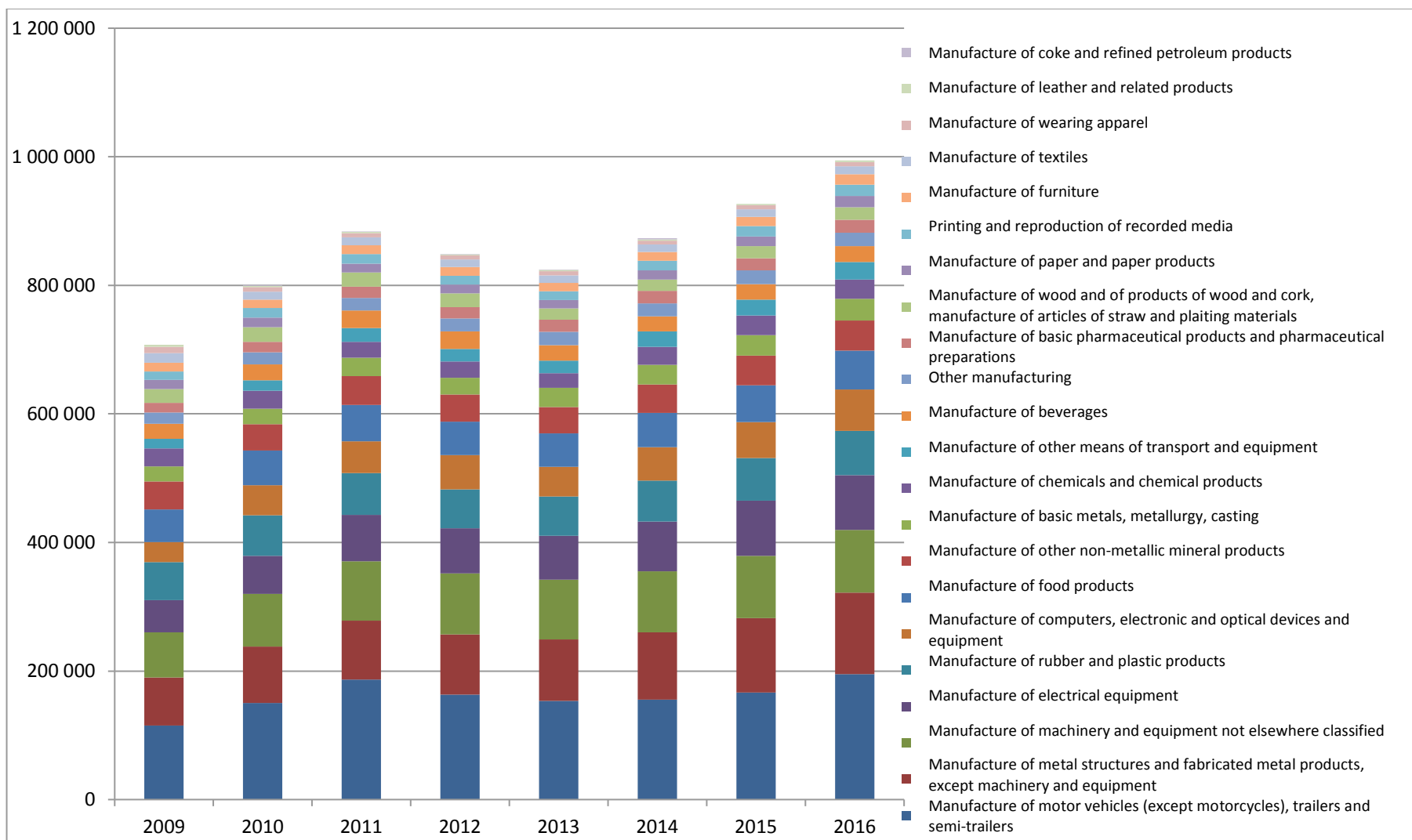
Of the more significant sectors (in terms of volume), we can further see a slight decrease in the share of the food processing industry in the total gross added value of the manufacturing industry (from approx. 8% in 2009 to approx. 5% in 2015).

Fig. 1.7 then shows developments in employment in the individual sectors of the manufacturing industry, and Figure 1.8 follows developments in employment structure in these sectors.

The development of the number of persons employed in the manufacturing industry roughly follows the overall development of gross added value. Year-on-year increases in the number of workers in 2010 and 2011 alternated with year-on-year downturns in 2012 and 2013, followed by recurring increases in 2014 and 2015. The number of people employed in the three most important sectors (manufacture of motor vehicles, manufacture of metal constructions and metal products, manufacture of machinery and equipment not referred to elsewhere) increased between 2009 and 2015, and more than 400 thousand persons worked in these three sectors alone in 2015. Their share in the total number of workers has also been growing, and employees in these three sectors accounted for more than 40% of all persons employed in the manufacturing industry.

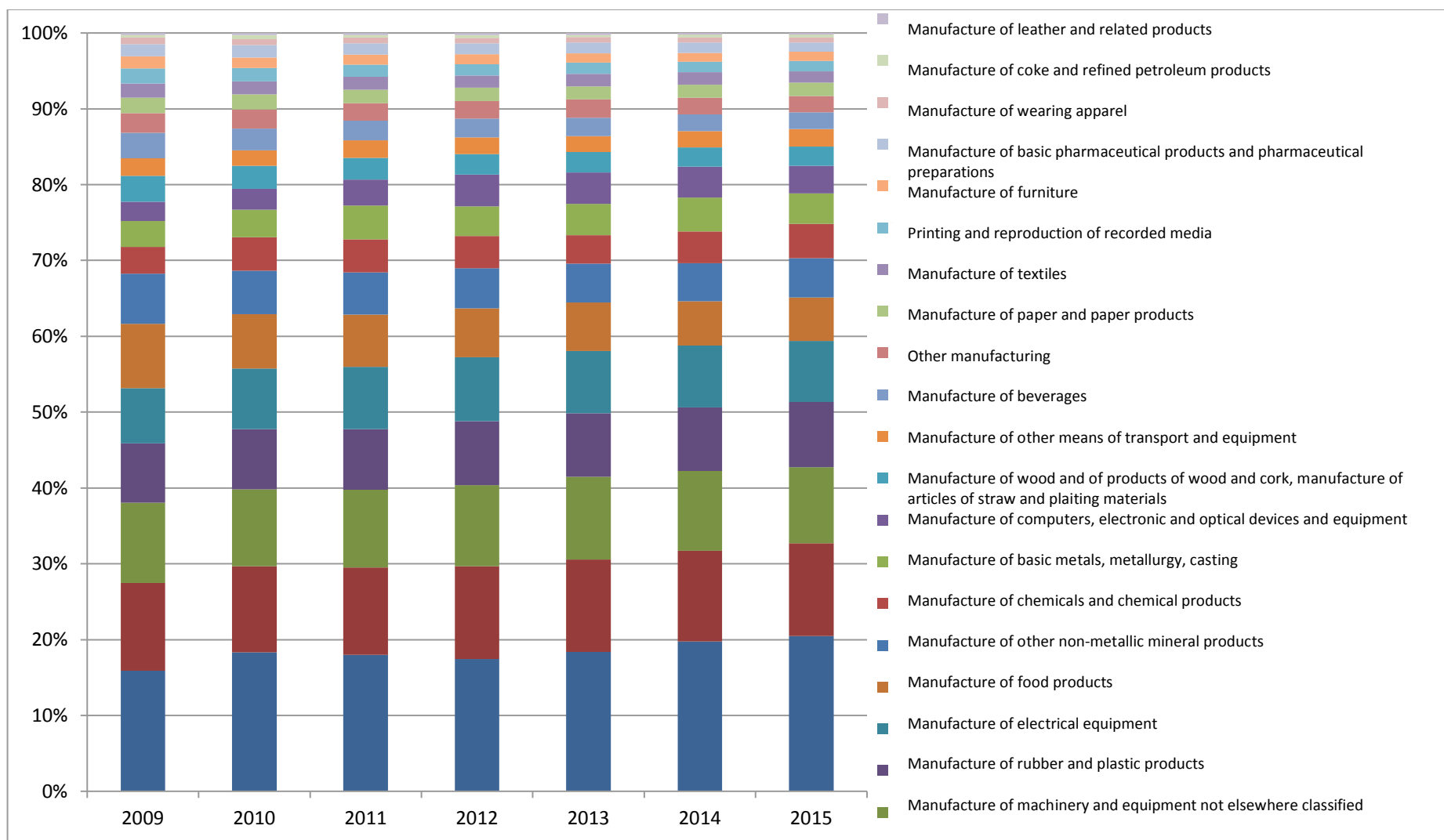
We note that while the manufacturing industry accounted for more than 20% of the gross added value of the manufacturing industry, persons employed in the manufacture of motor vehicles sector only represented about 15% of the total number of persons employed in the manufacturing industry. This is related to the above-average work productivity compared to other sectors within the manufacturing industry. The growth of this sector then contributes to the growth of productivity of the manufacturing industry, on which we will comment further in Chapter 3 of our study.

Fig. 1.5: Gross added value volume (at constant prices) of the manufacturing industry in the Czech Republic in 2009-2016 (CZK million)



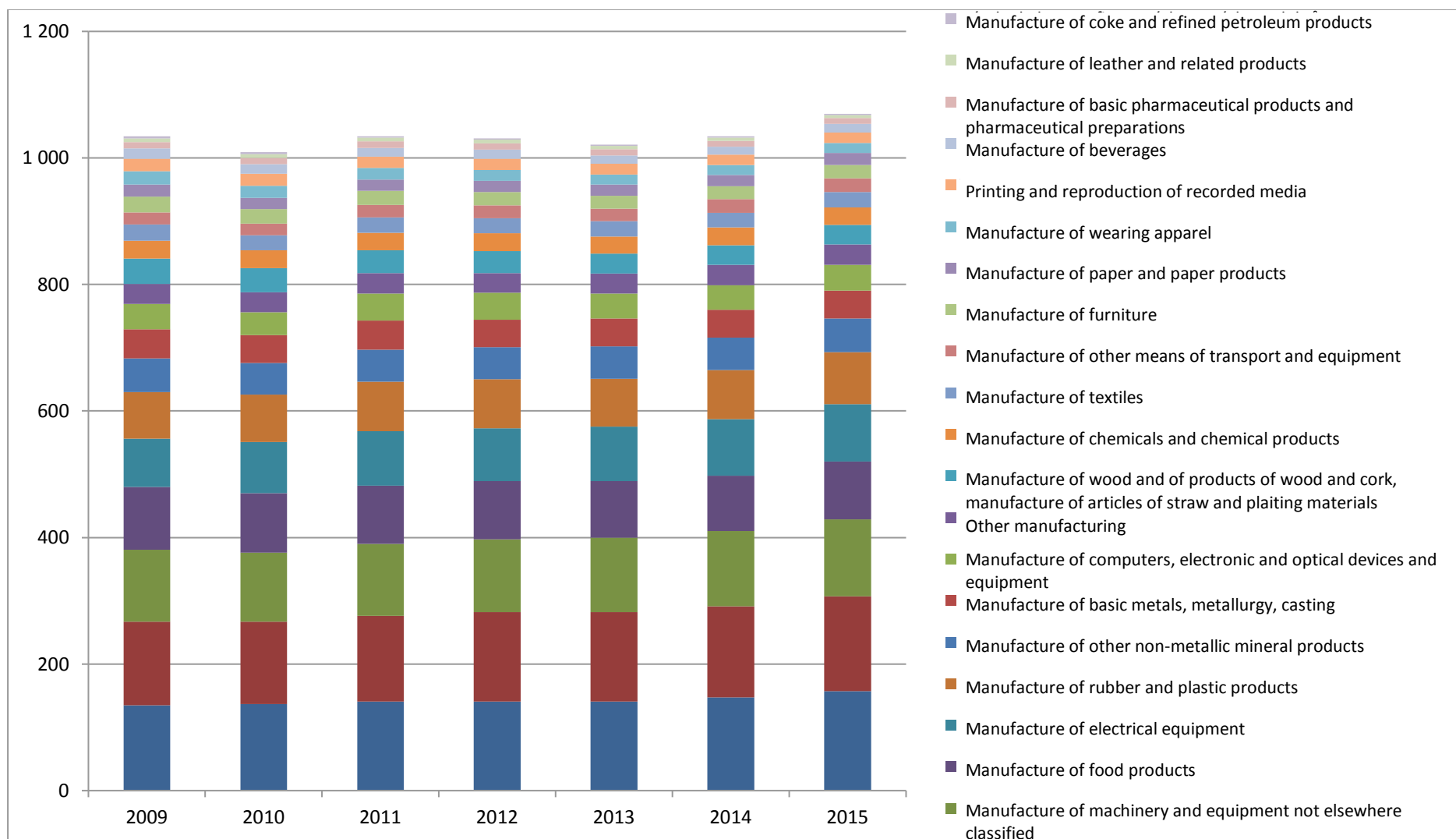
Source: Own figure created using Czech Bureau of Statistics data, Industry, energy sectors - Industry sector economic results

Fig. 1.6: Gross added value structure (at current prices) of the manufacturing industry in the Czech Republic in 2009-2015



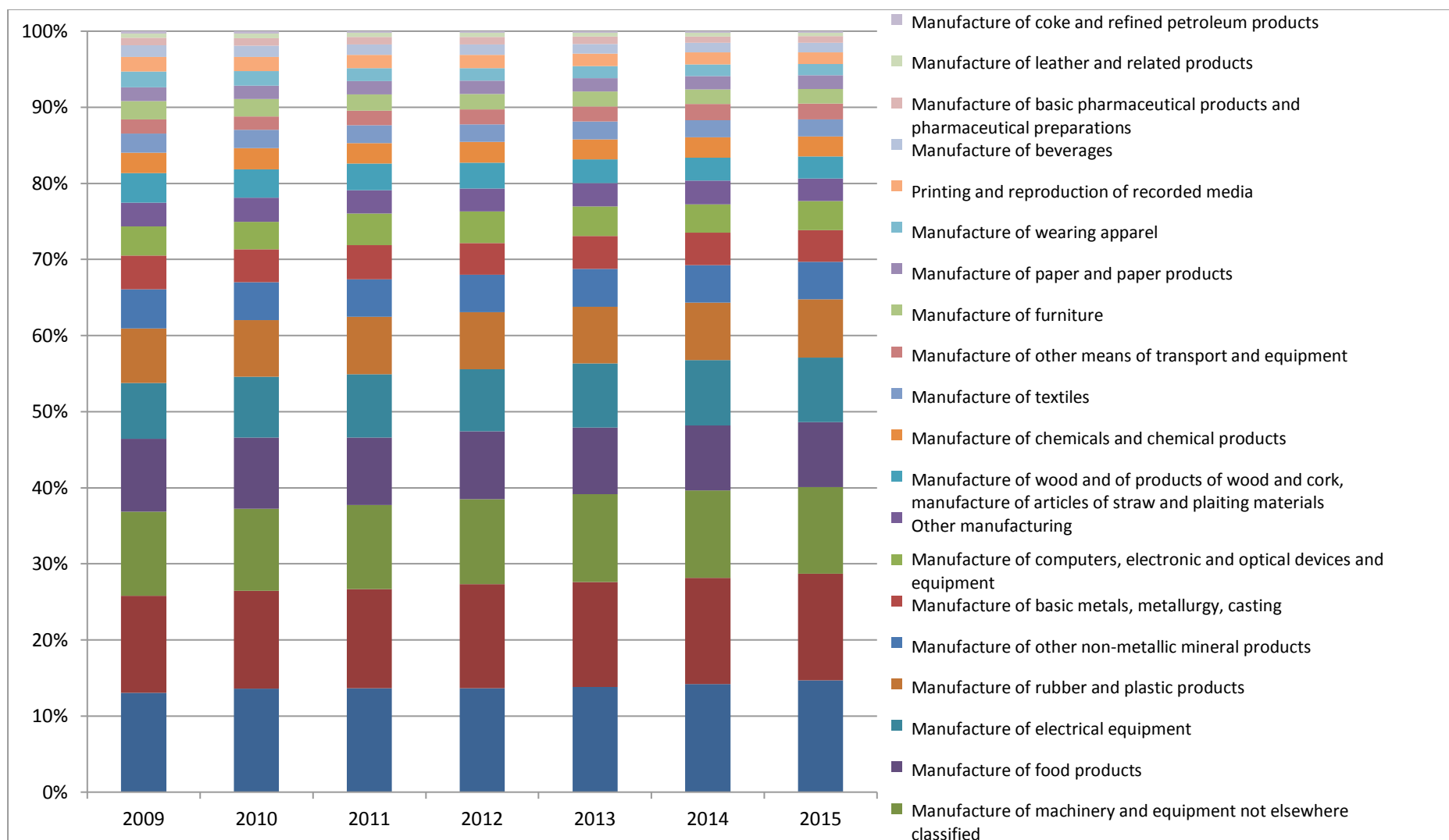
Source: Own figure created using Czech Bureau of Statistics data, Industry, energy sectors - Industry sector economic results

Fig. 1.7: Number of persons employed in sectors of the manufacturing industry in the Czech Republic in 2009-2015 (thousands)



Source: Own figure created using Czech Bureau of Statistics data, Industry, energy sectors - Industry sector economic results

Fig. 1.8: Number of persons employed in sectors of the manufacturing industry in the Czech Republic in 2009-2015 (%)



Source: Own figure created using Czech Bureau of Statistics data, Industry, energy sectors - Industry sector economic results

At the end of Chapter 1, we will briefly discuss the age structure of employment, as this is a very important antecedent for assessing the conformity of the number of employed persons on the one hand, and the number of graduates on the other hand, which will be discussed in the following chapter.

Unfortunately, data on the age structure is not available in a breakdown more detailed than that according to CZ-NACE sectoral classification, and it is therefore not possible to assess the age structure in particular at the level of the individual segments within the manufacturing industry.

Tab. 1.1 shows an uneven age group in selected industries. For instance, note Mining and quarrying sector, where 58% of all employees is in the two oldest age groups - 45-59 years and 60 and over, respectively. This, however, is not necessarily a negative thing given the gradual phase-out of this sector which has been in progress in recent years and which is likely to characterize the next few years as well.

For a more accurate interpretation of Tab.1.1, please note that the age groups are unevenly sized in the table and we believe that it is most appropriate to compare relative frequency in the 30-44 years of age group and the 45-59 years of age group. Significant differences in the representation of the two groups, especially the case where the 45-59 years of age group is more represented than the 30-44 years of age group, may signal a certain future "wave" in the number of workers employed in the relevant sector. This applies not only to the Mining and quarrying sector, where the number of workers aged 45-59 outnumbers workers in the 30-44 years of age group by nearly a half, as well as the real estate sector. In the latter sector, the 45-59 years of age group is larger than the 30-44 age group by approximately a quarter, and there is very low representation of workers in the youngest age groups (only 9% of employees are under the age of 29, inclusive).

The last two sectors that ought to be examined in terms of the age structure of persons employed therein are the sector of administrative and auxiliary services, and in particular the education sector; we will address the aging of teachers in Chapter 4 of our study.

In other sectors, the age structure of persons employed therein does not in itself indicate a major problem or a major future fluctuation.

Tab. 1.1 Age structure of persons employed in individual CZ-NACE sectors, 2016

Sector	15 - 24	25 - 29	30 - 44	45 - 59	60 and more
Agriculture, forestry and fisheries	4%	7%	36%	41%	12%
Mining and quarrying	2%	5%	35%	50%	8%
Processing industry	8%	11%	43%	32%	5%
Generation and distribution of electricity, gas, heat	3%	10%	36%	41%	10%
Water supply; activities related to waste	3%	8%	40%	40%	10%
Construction	4%	8%	44%	35%	8%
Wholesale and retail; repairs and maintenance of motor vehicles	7%	11%	42%	34%	6%
Transport and storage	5%	8%	41%	39%	7%
Accommodation, catering, hospitality	14%	13%	38%	29%	5%
Information and communication	5%	16%	57%	19%	3%
Finance and insurance	5%	14%	46%	29%	6%
Real estate	2%	7%	34%	42%	15%
Professional, scientific and technical activities	3%	10%	45%	30%	12%
Administration and support	5%	10%	35%	39%	11%
Public administration and defense; mandatory social security	2%	10%	42%	38%	9%
Education	2%	8%	38%	41%	10%
Health care and social services	3%	8%	40%	39%	10%
Culture, entertainment and recreation	6%	11%	37%	32%	14%
Other activities	7%	12%	40%	30%	10%

Source: Own table created using Czech Bureau of Statistics data, Employment, unemployment - Employment, unemployment according to Selective Labor Survey

2. Comparison of employment structure and structure of secondary vocational school graduates, Czech Republic, 2009-2016

2.1 Manufacturing industry sectors

This chapter compares developments in the structure of employment in the individual sectors of the national economy with the structure of graduates of secondary vocational schools, both in 2009-2016. These results naturally need to be interpreted with some caution. First of all, university graduates also enter the relevant sectors, and moreover, they enter the sectors with a delay of three to five years from their secondary school graduation. Second, there is intersectoral migration, where a particular post may be held even by a graduate in a related, and sometimes completely different, field of study. Third, to analyze the impact of the graduate structure on the future structure of employment, it was necessary to know the structure of the workers in terms of age, sector and qualifications, which information, unfortunately, cannot be gleaned from publicly available data at the required level of detail. Fourth, and finally, for a deeper analysis at the level of individual sectors (broken down by CZ-NACE subsections), it is necessary to give consideration to specific features of individual sectors, which, however, exceeds the possibilities afforded by the scope and analytical depth of this study. Despite that, we believe that the following comparisons, based on macroeconomic indicators of the Czech Bureau of Statistics on the one hand, and detailed statistics on the educational system output, kept by the Ministry of Education, Youth and Sports of the Czech Republic, on the other hand, will provide makers of economic, social and, above all, educational policies with at least a guideline for the formulation and implementation of relevant policies.

As regards macroeconomic indicators and statistics for schools, on the other hand, it was necessary to carry out certain expert aggregations for the requirements of our comparison, so as to make the data on macroeconomic indicators and educational indicators mutually comparable. In some cases, therefore, clusters of individual sectors were created, e. g., *Mining and quarrying, Manufacture of basic metals, metallurgy, casting*, were aggregated so that the data could be compared with data for graduates in fields of study pertaining to mining, metallurgy and casting.

Fig. 2.1 and 2.2 show us the development of employment and the number of graduates in *Mining and quarrying, Manufacture of basic metals, metallurgy, casting* sectors. Note the declining employment figures in the relevant sector (a drop in the number of employees by approx. 10,000 in 2009-2016) and a declining number of graduates with secondary education in the fields of *Mining and quarrying, Manufacture of basic metals, metallurgy, casting*, of whom there were fewer than 100 per year starting from 2012. The impact of secondary education on the reproduction of physical human capital in this area is therefore negligible. Either it will be sufficient to obtain people with only primary education, or some degree of migration will be required, or, which is most likely, there will be a more or less controlled phase-out of the entire sector within the economy.

The situation appears generally stabilized in the *Manufacture of beverages* and *Manufacture of food products* sectors. The number of workers declined more markedly between 2009 and 2011, and the figure for 2015 is virtually the same as that for 2011 (slightly over 100,000 workers, see Fig. 2.3). Number of graduates of secondary vocational education in the fields of *Food processing, food chemistry* (see Fig. 2.4) dropped significantly between 2009 and 2011, and has been growing slightly between 2011 and 2016 (unlike the total number of graduates of secondary vocational education, see Fig. 0.1). A simple reproduction of the labor under a stable age structure of workers would be ensured provided that the share of workers with secondary vocational education does not exceed approx. 60% (on the assumption that the average worker with vocational education works for 40 years on average).

In the manufacture of textiles and clothing (*Manufacture of wearing apparel, Manufacture of textiles*), we can see a steep drop in employment between 2009 and 2011, followed by a stabilization at approx. 40 thousand employees (Fig. 2.5). On the other hand, there is a dramatic decline in the number of graduates in the textile and clothing sectors (*Production of textiles and clothing*) in secondary education, where the number of graduates (provided as an aggregate of graduates with A-levels and CVE) dropped from an initial figure of approx. 1,000 in 2009 to 120 per year 2016 (Fig. 2.6). This means that in the course of seven years, the number of graduates in these fields of study dropped to approx. one eighth! Domestic sources of employment in this sector are therefore perfectly negligible in the upcoming years.

A completely different development of employment and secondary vocational education can be seen in the sectors of *Manufacture of rubber and plastic products* and *Manufacture of leather and related products*. While employment remained above 80,000 workers, with a slight increase between 2013 and 2015 (Fig. 2.7), the number of graduates of secondary vocational

education in the fields of *Manufacture of leather products and footwear and processing of plastics* fell from the initial figure of over 140 in 2009 to the final 11 in 2016 (Fig. 2.8) . Secondary education provided in the Czech Republic is therefore not relevant at all to the procurement of labor in the above-mentioned sectors (especially in the sector of manufacture of rubber and plastic products).

After a steady decline between 2009 and 2013 (from approx. 65 thousand to approx. 52 thousand), the *Manufacture of wood and of products of wood and cork, manufacture of articles of straw and plaiting materials, Manufacture of furniture* sectors have stabilized at a level slightly in excess of 50 thousand in 2013 (Fig. 2.9). Nevertheless, the number of secondary vocational education graduates in the fields of *Wood processing, manufacture of musical instruments* has been declining steadily throughout 2009-2016, falling to approx. 1 thousand graduates in 2016 (Fig. 2.10). Therefore, the "supply" of the labor market in the wood-processing and furniture-making sectors with fresh graduates is generally secure (the ratio of the number of secondary vocational education graduates to the total number of employees being approx. 2%) but the number of graduates must not drop too much below the 2016 level.

After an initial decrease in 2009-2011, the number of workers in the printing and paper-making sectors (*Manufacture of paper and paper products and Printing and reproduction of recorded media*) has stabilized at approx. 35 thousand (Fig. 2.11). As regards the number of graduates in printing and film processing fields of study, different developments can be observed in CVE and A-level programs, respectively (Fig. 2.12). While numbers of graduates from A-level programs were generally stable in the 2009-2016 period under observation, with 350-400 graduates per year, the number of graduates from CVE programs dropped significantly between 2011 and 2013, with the number of graduates declining by two thirds to approx. 100 in the course of two years; the number of graduates from CVE programs remained at this level until 2016. The decrease in the number of graduates from CVE programs also contributed to the overall decrease of the number of secondary vocational education graduates; in 2016, there were 500 such graduates and they accounted for approx. 0.7% of the total workforce in the printing and paper-making sectors.

The number of workers in "chemical" sectors, *Manufacture of coke and refined petroleum products, Manufacture of chemicals and chemical products and Manufacture of other non-metallic mineral products*, oscillated around 80 thousand in 2009-2015, with a slight decline at the beginning of the monitored period and a slight increase at the end (Fig. 2.13). Between 2009 and 2014, the number of secondary vocational school graduates in the fields of *Technical*

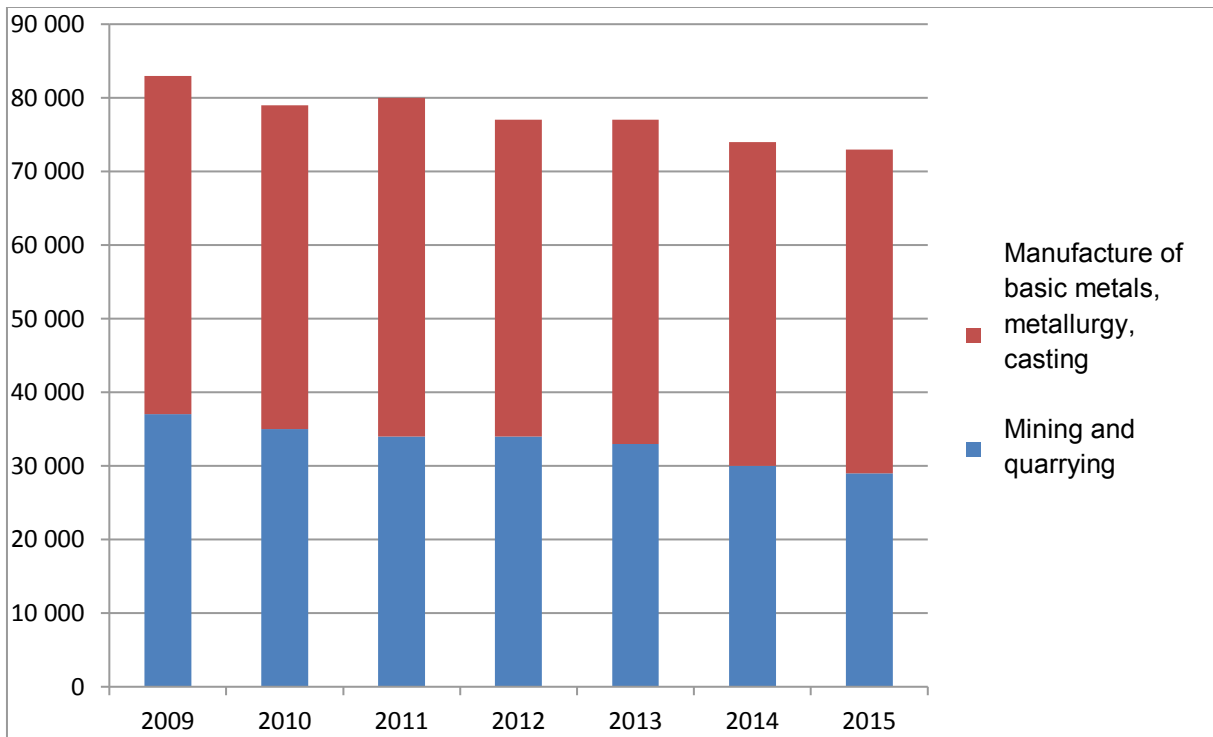
chemistry and chemistry of silicates declined from the initial number of over six hundred to approx. 400, followed by a slight increase in the next two years (Fig. 2.14). An overwhelming majority of graduates have obtained a full secondary education. The ratio of the number of graduates in chemical fields is only slightly above the level of 0.5% of the total number of employees in the pertinent sectors. Therefore, the labor market in the given sectors is sustainable only if university graduates enter the labor market in a sufficient number.

One of the key industries in connection with the Industry 4.0 initiative will be *Manufacture of electrical equipment* and *Manufacture of computers, electronic and optical devices and equipment*. In this sector, we see completely contradictory tendencies as regards the number of employees on the one hand, and the number of graduates in relevant fields on the other hand. The number of workers in these sectors has been growing virtually without interruption between 2009 and 2015 (unlike in most of the other field described in this part of the study, as most of them have exhibited an absolute decline in employment over the 2009-2011 time period), from approx. 117 thousand in 2009 to about 130 thousand in 2015 (Fig. 2.15). On the other hand, the number of graduates with a CVE and A-levels in the fields of *Electrical engineering, telecommunications and computer science* fell from the initial figure of less than 9 thousand in 2009 to approx. 3,800 in 2016 (Fig. 2.16). If in 2009, secondary school graduates accounted for 7.5% of the total workforce in related fields, this ratio was a mere 2.9% in 2016. Note that while the number of graduates with a CVE remains virtually constant between 2010 and 2016, being approx. 2000, the number of graduates with A-levels has dropped dramatically, from more than 6 thousand in 2009 to less than two thousand in 2016, which means that over a period of seven years, there was a decline by more than two thirds. Without a detailed analysis of the age-qualification structure, it cannot be said unequivocally whether the number of graduates in given fields suffices to meet the demand for labor in electrical engineering sectors; however, given the projected increase in demand for labor, which, given the nature of the sector, will tend towards younger workers, the current development trends as regards the number of workers and the number of graduates is a matter of concern.

We are not surprised by the significant absolute and relative increase in the number of workers in engineering and automotive industries, specifically, in *Manufacture of metal structures and fabricated metal products, except machinery and equipment*, *Manufacture of machinery and equipment not elsewhere classified*, *Manufacture of motor vehicles (except motorcycles), trailers and semi-trailers* and *Manufacture of other means of transport and equipment*. The number of employees grew from the initial 400 thousand in 2009 to 450 thousand in 2015 (Fig.

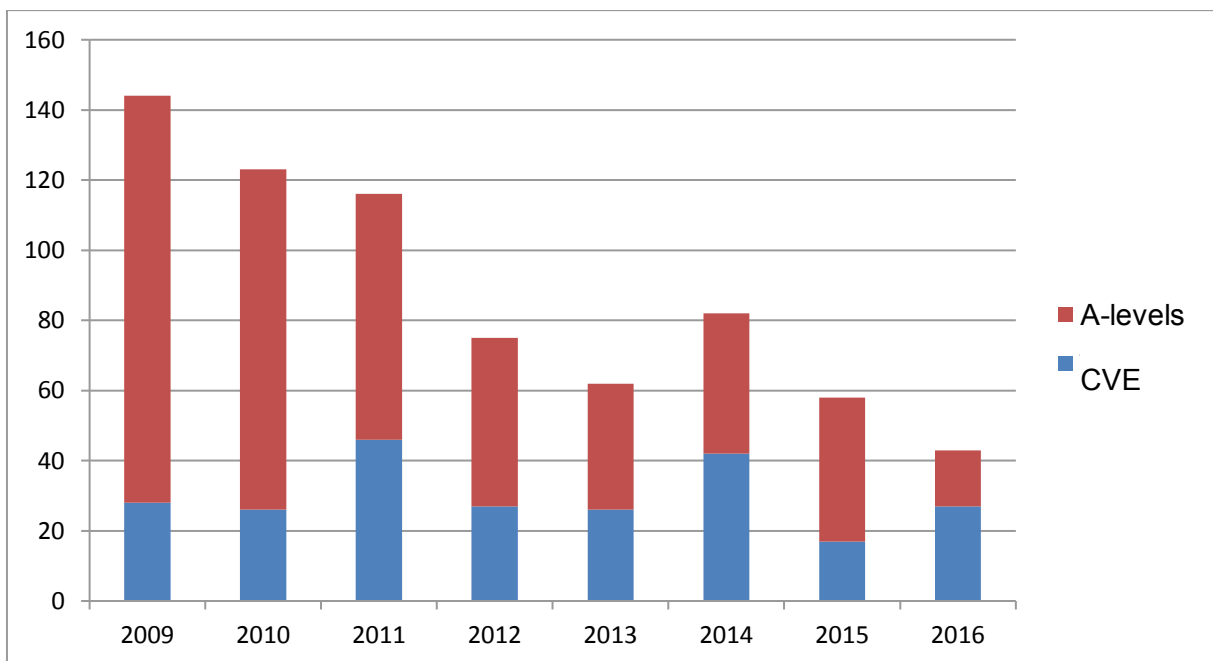
2.17), which makes it the sector with the absolutely highest number of workers and the highest absolute increase in the number of workers (+ 50 thousand). The increase was evenly distributed across all four sectors within the engineering and automotive industries. The number of graduates with secondary vocational education exhibited an opposite trend. While in 2009, less than 11 thousand graduated in Engineering, engineering production, in 2016, the number of graduates did not reach even seven thousand (Fig. 2.18). This downturn concerned both graduates with a CVE and graduates with A-levels. The ratio of graduates with secondary vocational education to total number of workers dropped from 2.7% in 2009 to 1.5% in 2015. Although the decline in the number of graduates has stopped in 2014 already, given the steadily growing demand, the number of secondary vocational school graduates will presumably not be sufficient to meet the demand. Moreover, there is a regional subtext to the issue, which nevertheless goes beyond the scope and possibilities of this study.

Fig. 2.1: Developments in the number of employees in Mining and quarrying, Manufacture of basic metals, metallurgy, casting, 2009-2015, Czech Republic



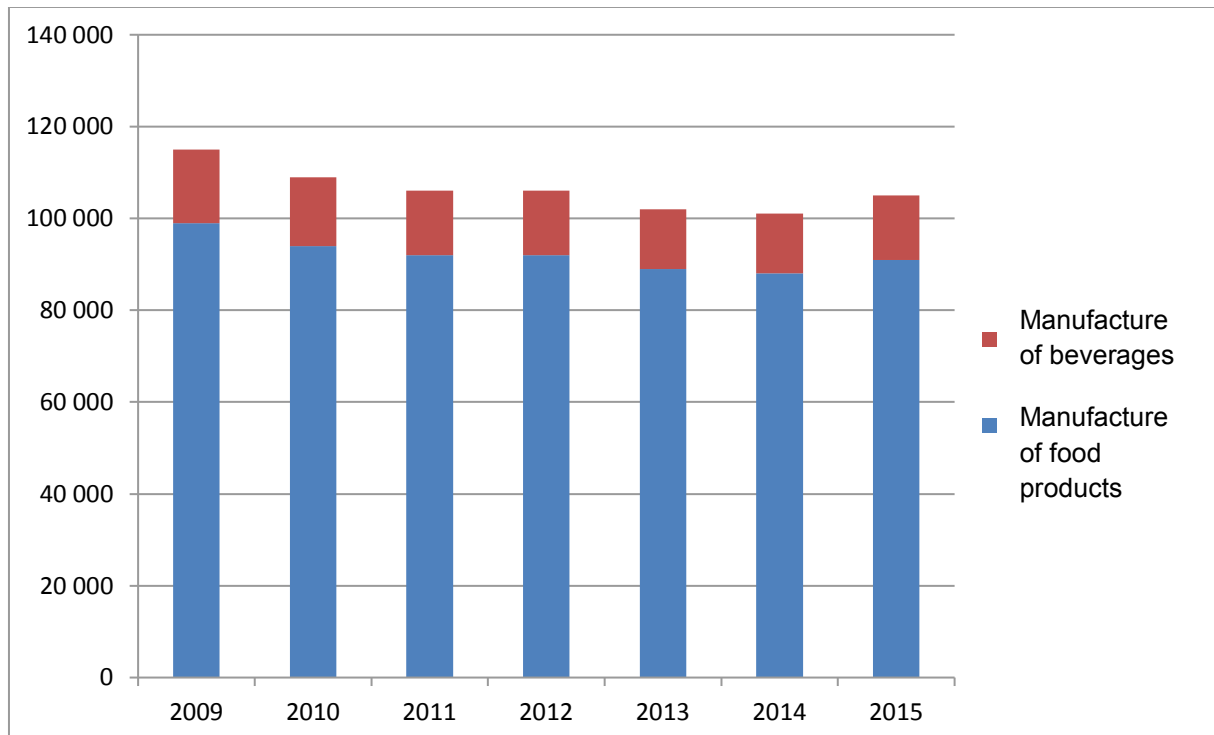
Source: Own figure created using Czech Bureau of Statistics data, Industry, energy sectors - Industry sector economic results

Fig. 2.2: Developments in the number of graduates with a CVE and A-levels in Mining, metallurgy, casting, 2009-2016, Czech Republic



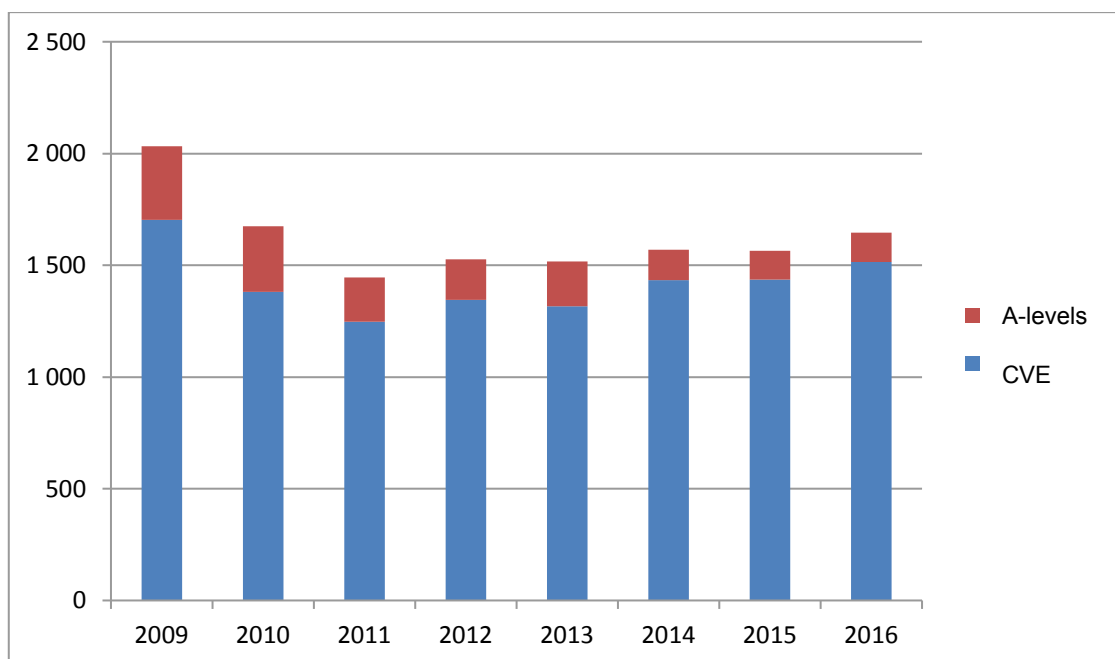
Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Fig. 2.3: Developments in the number of employees in Manufacture of beverages and Manufacture of food products, 2009-2015, Czech Republic



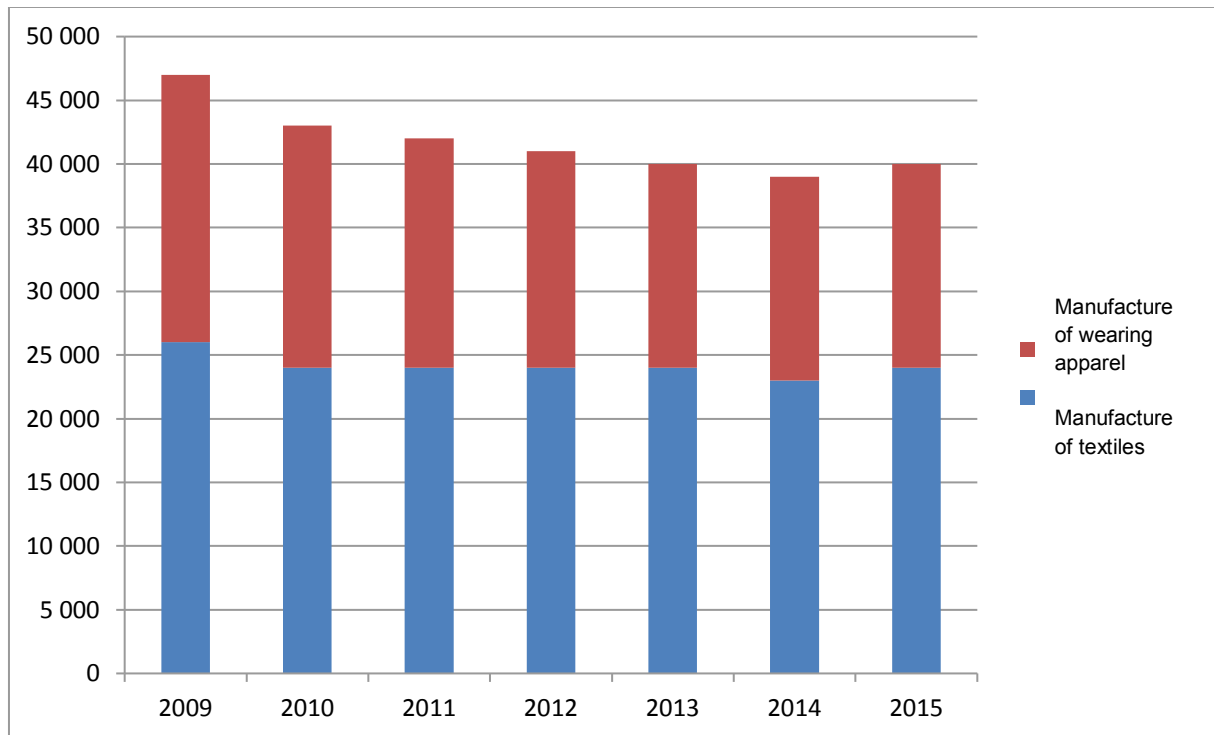
Source: Own figure created using Czech Bureau of Statistics data, Industry, energy sectors - Industry sector economic results

Fig. 2.4: Developments in the number of graduates with a CVE and A-levels in Food processing, food chemistry, 2009-2016, Czech Republic



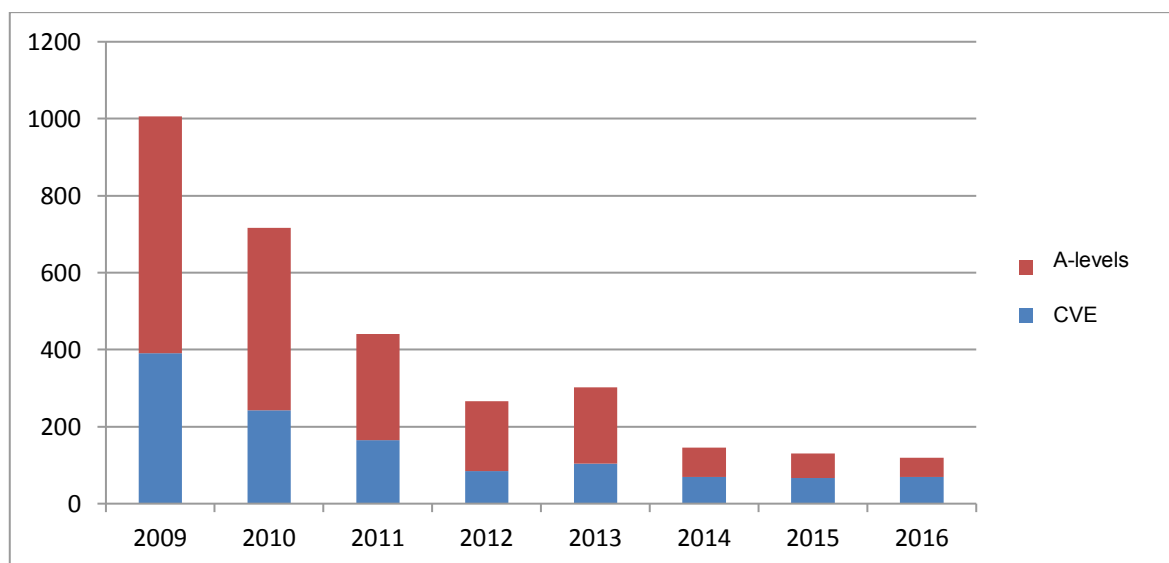
Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Fig. 2.5: Developments in the number of employees in Manufacture of wearing apparel, Manufacture of textiles, 2009-2015, Czech Republic



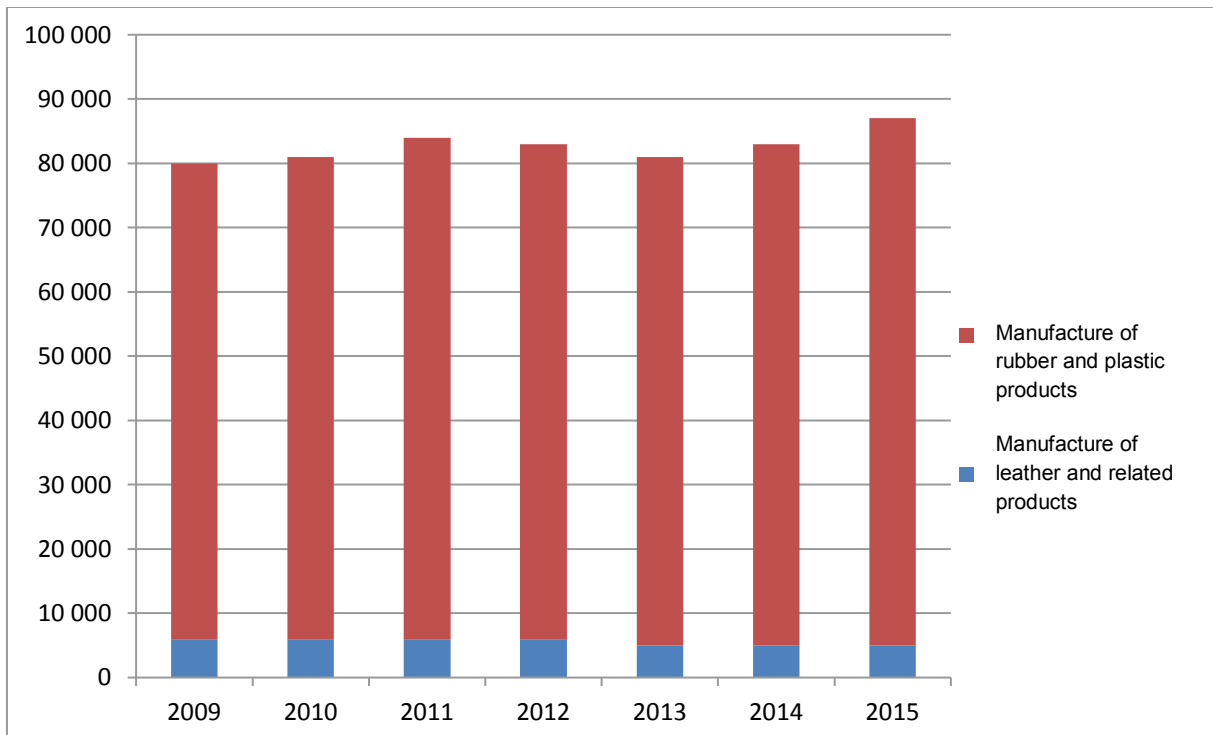
Source: Own figure created using Czech Bureau of Statistics data, Industry, energy sectors - Industry sector economic results

Fig. 2.6: Developments in the number of graduates with a CVE and A-levels in Production of textiles and clothing, 2009-2016, Czech Republic



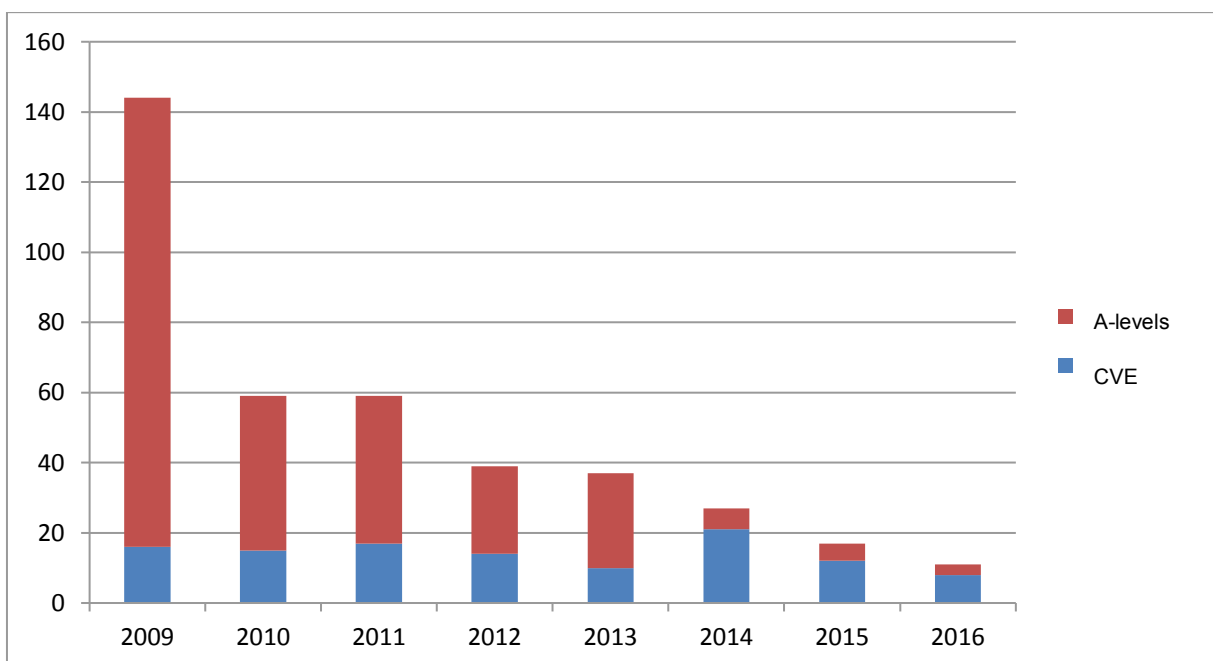
Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Fig. 2.7: Developments in the number of employees in Manufacture of rubber and plastic products and Manufacture of leather and related products, 2009-2015, Czech Republic



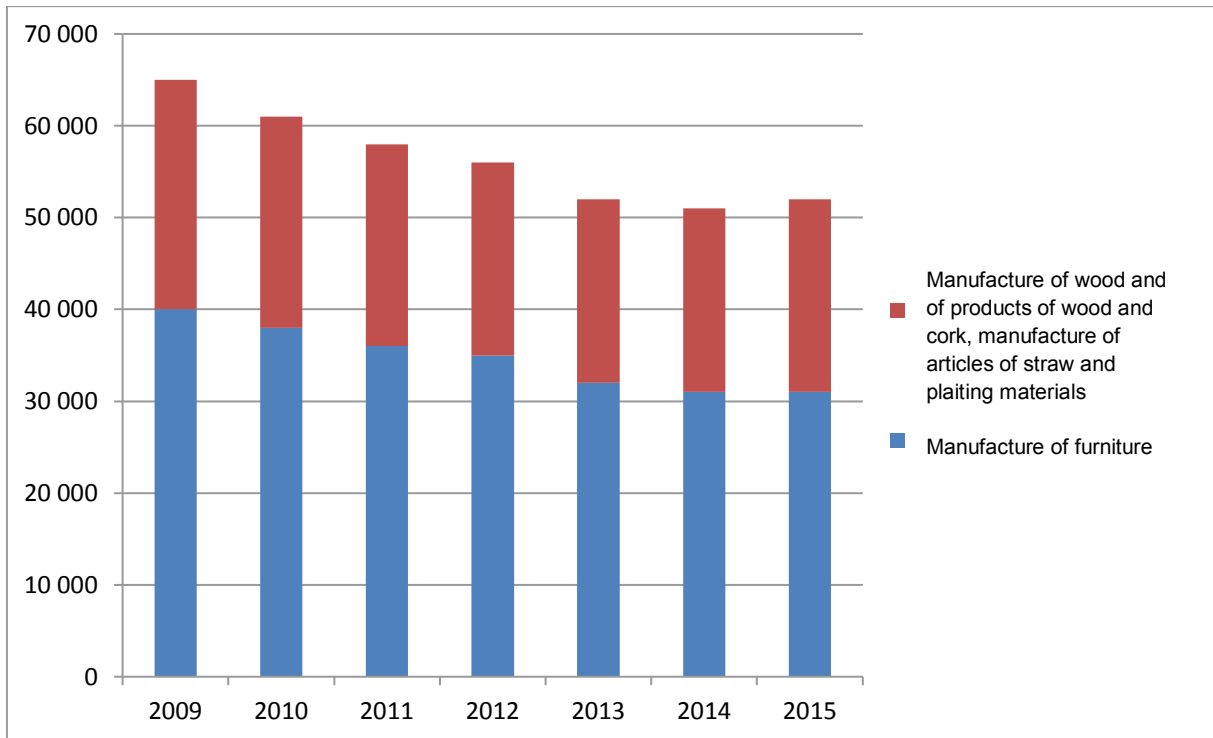
Source: Own figure created using Czech Bureau of Statistics data, Industry, energy sectors - Industry sector economic results

Fig. 2.8: Developments in the number of graduates with a CVE and A-levels in Manufacture of leather products and footwear and processing of plastics, 2009-2016, Czech Republic



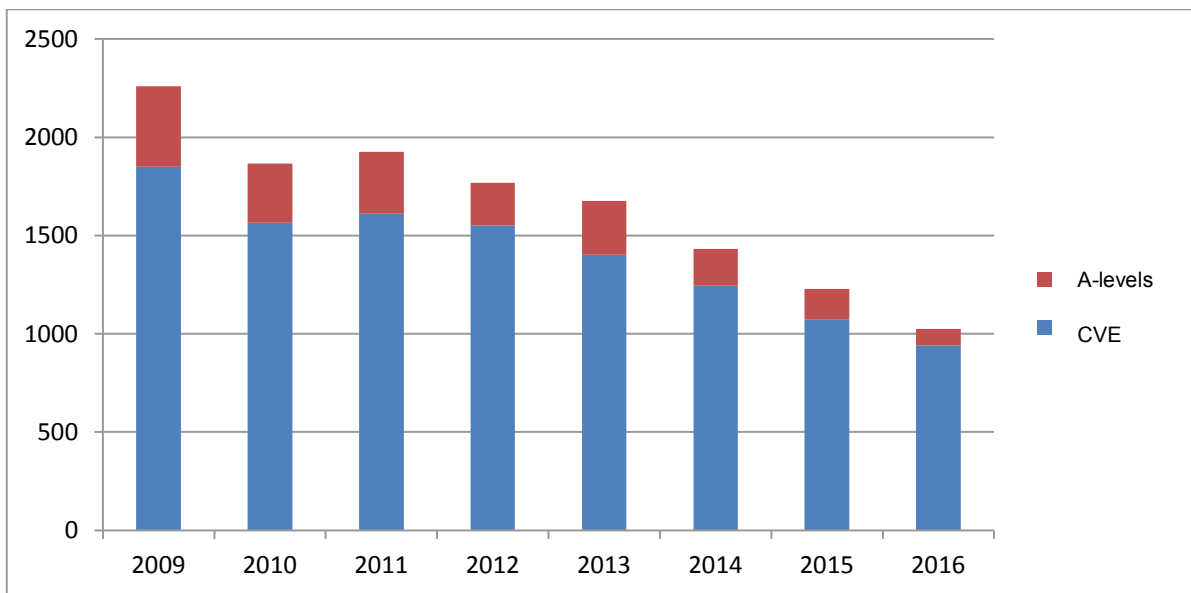
Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Fig. 2.9: Developments in the number of employees in Manufacture of wood and of products of wood and cork, manufacture of articles of straw and plaiting materials, Manufacture of furniture, 2009-2015, Czech Republic



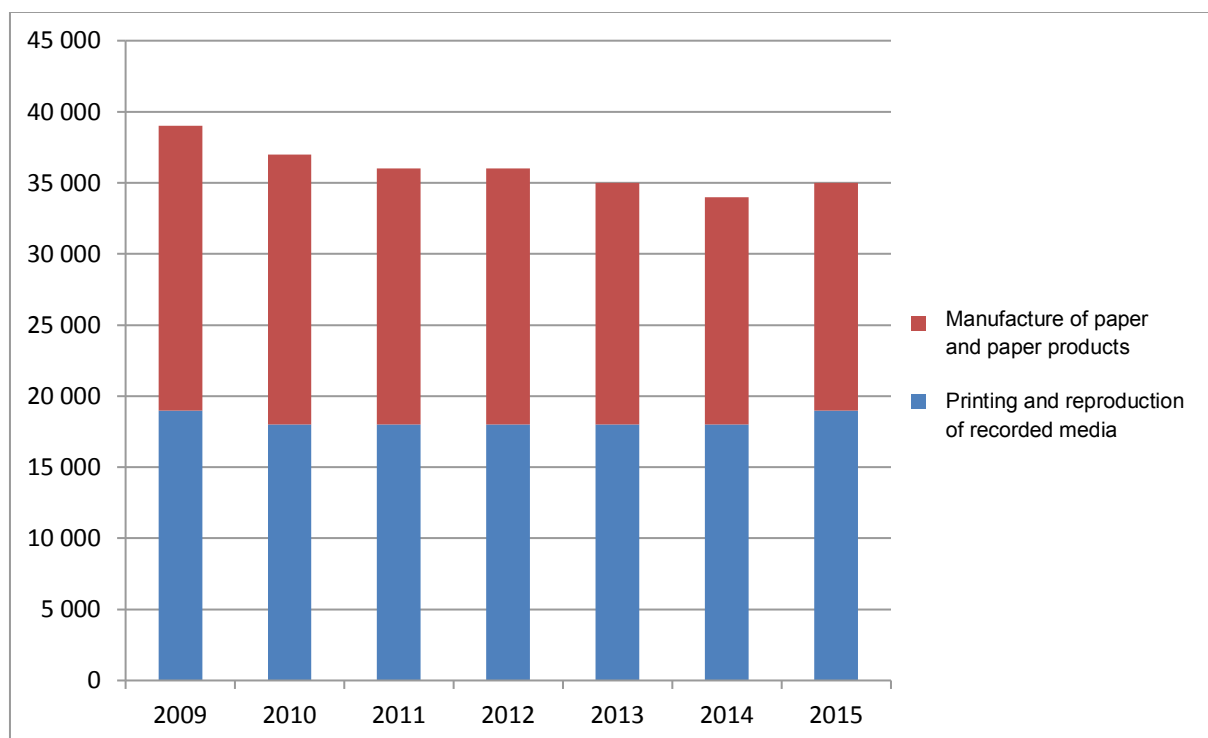
Source: Own figure created using Czech Bureau of Statistics data, Industry, energy sectors - Industry sector economic results

Fig. 2.10: Developments in the number of graduates with a CVE and A-levels in Wood processing, manufacture of musical instruments, 2009-2016, Czech Republic



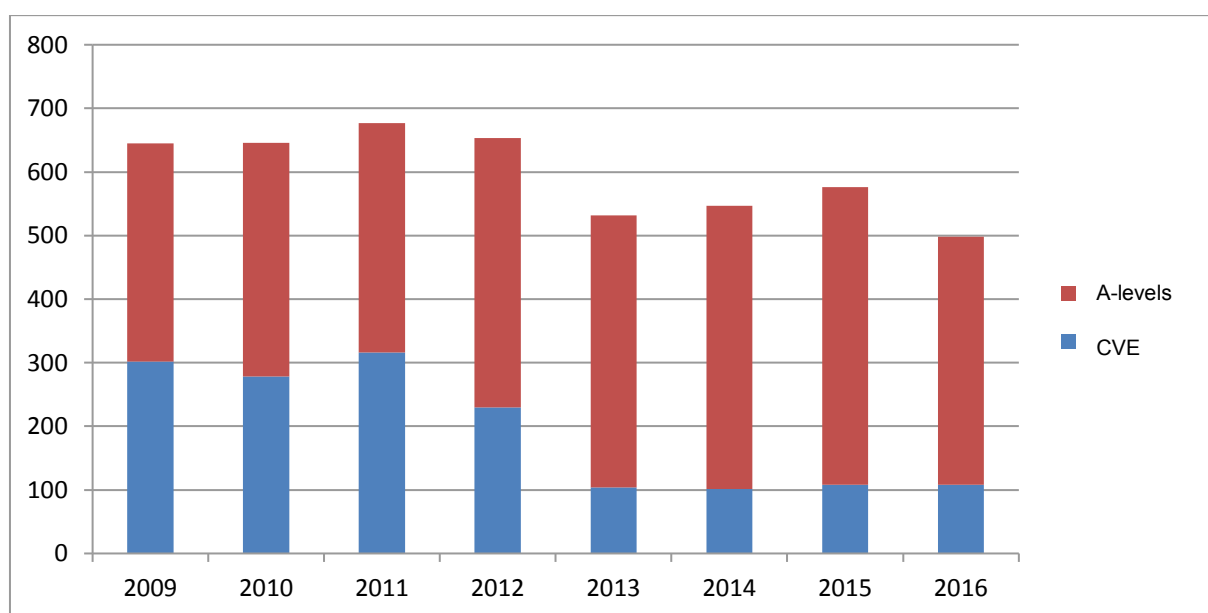
Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Fig. 2.11: Developments in the number of employees in Manufacture of paper and paper products and Printing and reproduction of recorded media, 2009-2015, Czech Republic



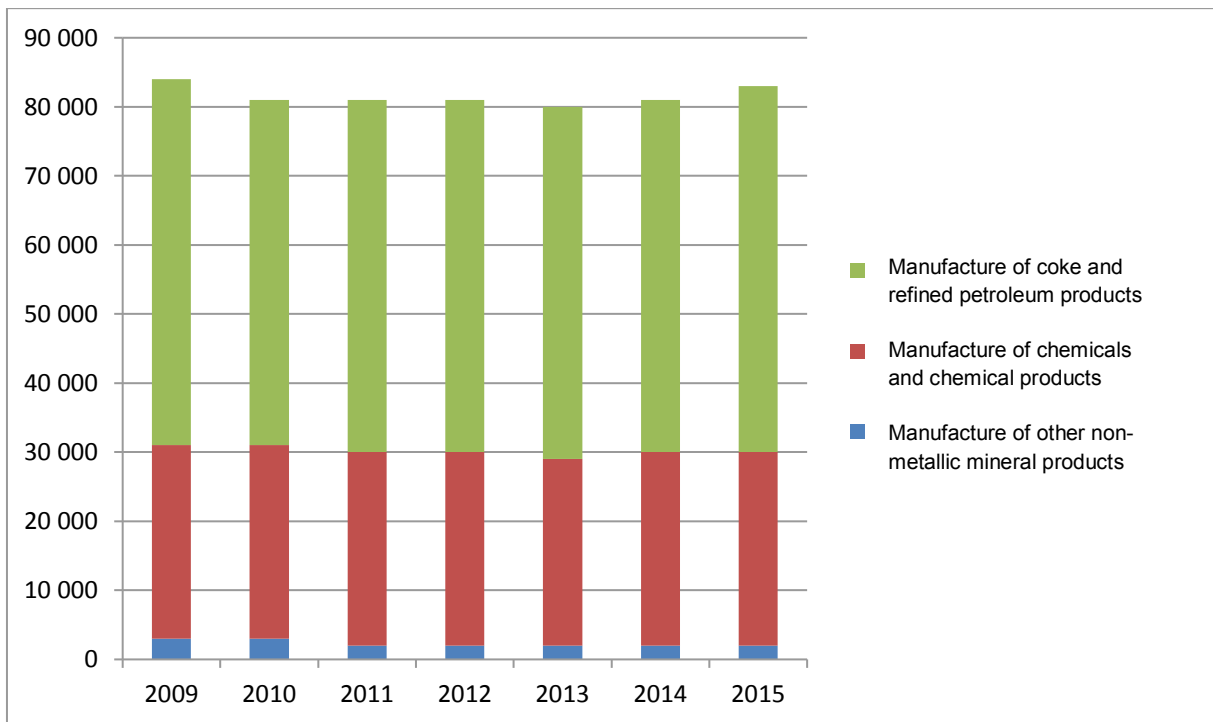
Source: Own figure created using Czech Bureau of Statistics data, Industry, energy sectors - Industry sector economic results

Fig. 2.12: Developments in the number of graduates with a CVE and A-levels in Printing, paper processing, film processing, 2009-2016, Czech Republic



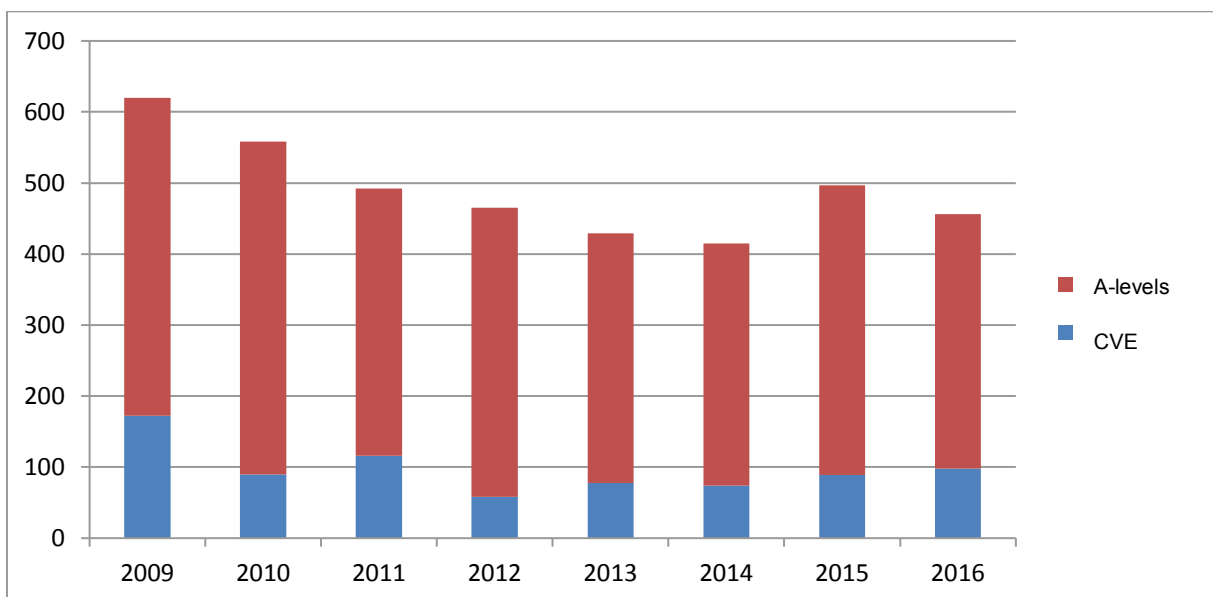
Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Fig. 2.13: Developments in the number of employees in Manufacture of coke and refined petroleum products, Manufacture of chemicals and chemical products and Manufacture of other non-metallic mineral products, 2009-2015, Czech Republic



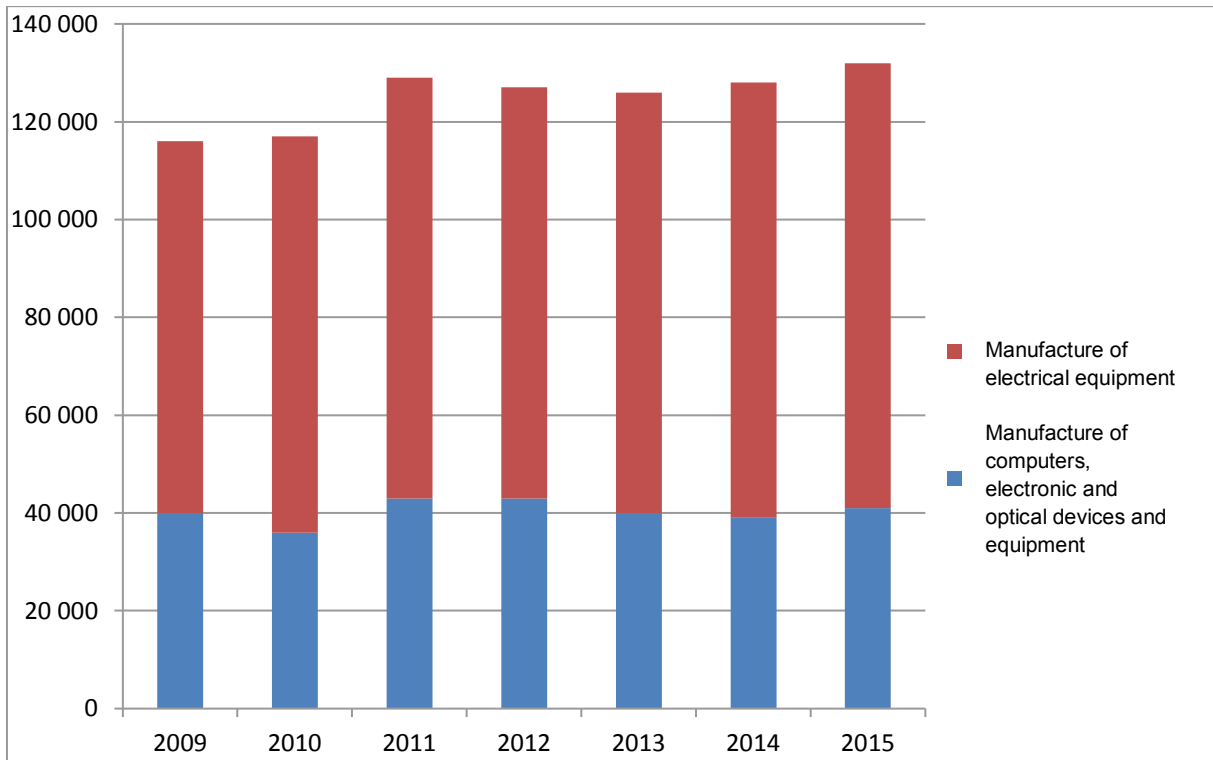
Source: Own figure created using Czech Bureau of Statistics data, Industry, energy sectors - Industry sector economic results

Fig. 2.14: Developments in the number of graduates with a CVE and A-levels in Technical chemistry and chemistry of silicates, 2009-2016, Czech Republic



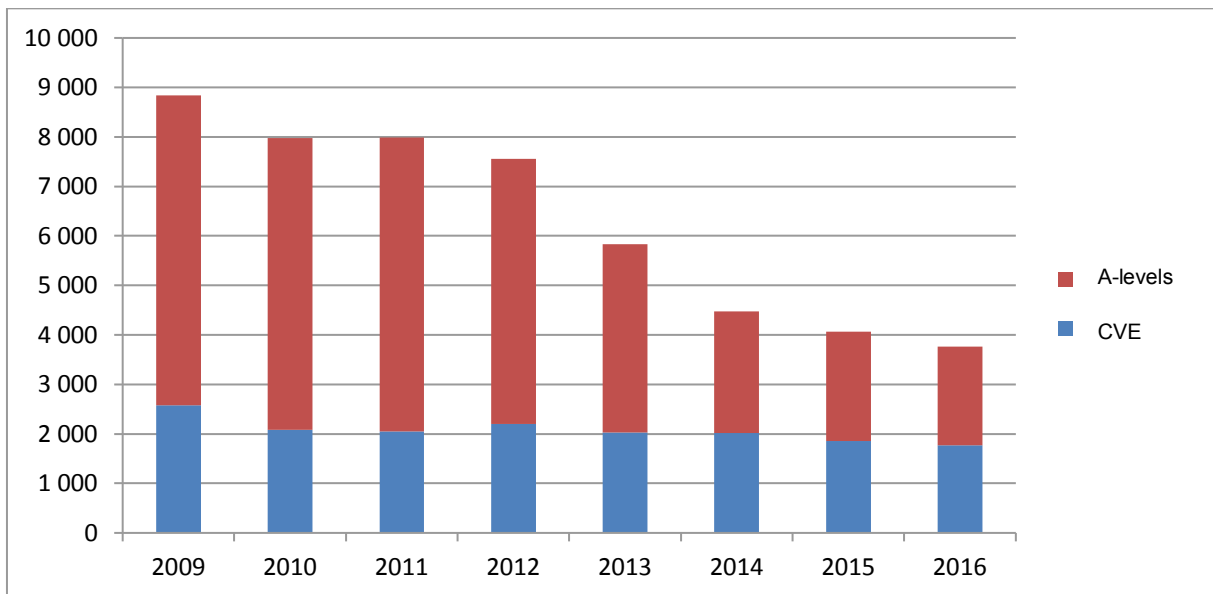
Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Fig. 2.15: Developments in the number of employees in Manufacture of electrical equipment, Manufacture of computers, electronic and optical devices and equipment, 2009-2015, Czech Republic



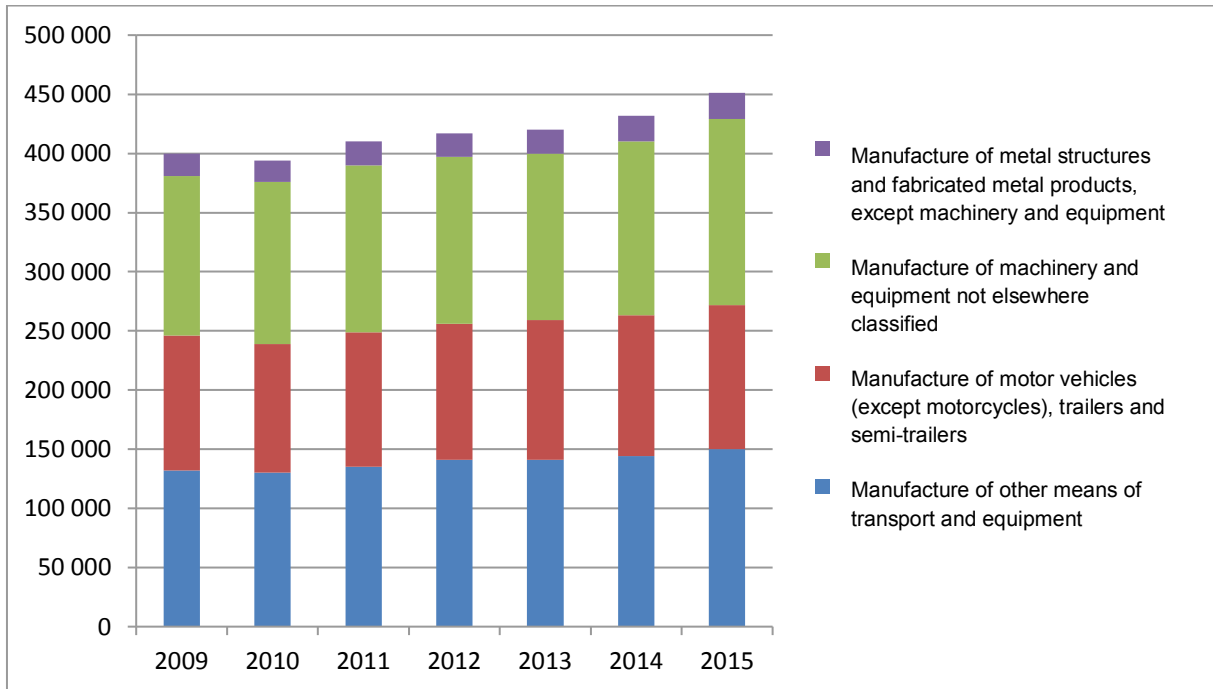
Source: Own figure created using Czech Bureau of Statistics data, Industry, energy sectors - Industry sector economic results

Fig. 2.16: Developments in the number of graduates with a CVE and A-levels in Electrical engineering, telecommunications and computer science, 2009-2016, Czech Republic



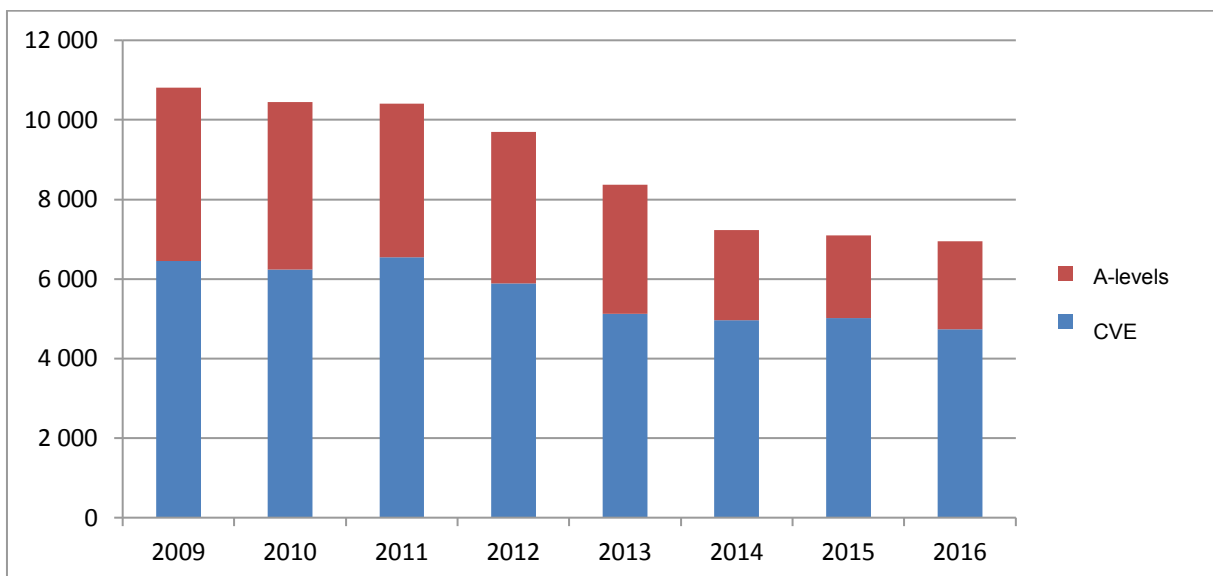
Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Fig. 2.17: Developments in the number of employees in Manufacture of metal structures and fabricated metal products, except machinery and equipment, Manufacture of machinery and equipment not elsewhere classified, Manufacture of motor vehicles (except motorcycles), trailers and semi-trailers, Manufacture of other means of transport and equipment, 2009-2015, Czech Republic



Source: Own figure created using Czech Bureau of Statistics data, Industry, energy sectors - Industry sector economic results

Fig. 2.18: Developments in the number of graduates with a CVE and A-levels in Engineering, engineering production, 2009-2016, Czech Republic



Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

2.2 Other selected market sectors of the national economy

Due to a higher degree of aggregation, data for 2016 is also available, and the number of employees and the number of graduates at the level of CZ-NACE sections is therefore also observed for the 2009-2016 period.

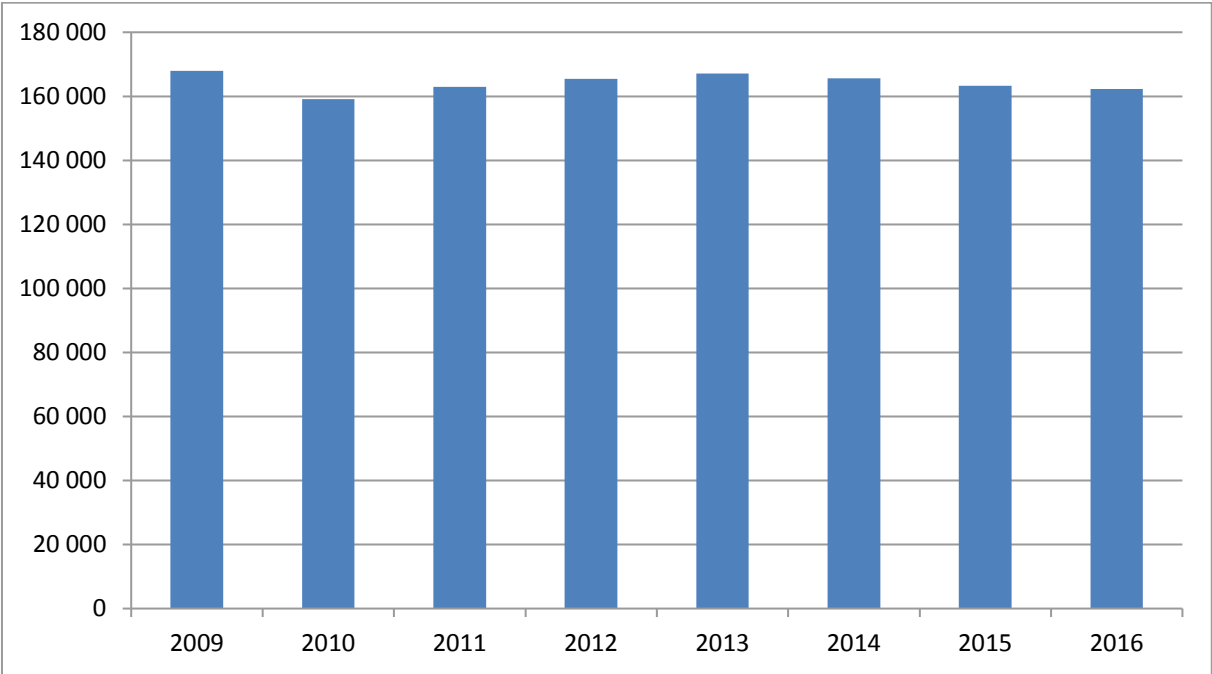
One of the few sectors in which we register a stable development in the number of workers in 2009-2016 is *Agriculture, forestry, fisheries* (Fig. 2.19). The number of employees in this sector has been oscillating around 160 thousand, and the actual number of persons employed (including self-employed persons) is higher by about 50 thousand, taking self-employed farmers into account. The number of secondary vocational education graduates in the fields of *Agriculture and forestry* has been declining in the period under review, with the exception of 2012, from 4.5 thousand in 2009 to approx. 3 thousand in 2016 (Fig. 2.20). While the number of graduates with a CVE has generally stagnated, the number of graduates with full secondary education has been dropping significantly. In 2016, the number of graduates with secondary vocational education reached 1.7% of the total number of workers.

In terms of the number of employees, *Construction* sector exhibits a reverse mirror development as compared to engineering and automotive sectors. While the number of employees in engineering and automotive sectors increased from 400 thousand to 450 thousand in 2009-2015 (as described above), the number of employees in construction declined from approx. 460 thousand in 2009 to approx. 405 thousand in 2016 (Fig. 2.21). This is the sector with the highest absolute decrease of the number of workers. The number of graduates in *Construction, geodesy, cartography* has been declining steadily from 2012 to 2016 (from approx. 5.2 thousand in 2012 to approx. 3.3 thousand in 2016). Both graduates with a CVE and graduates with A-levels (Fig. 2.22) contributed to the decline. The number of secondary vocational education graduates thus dropped to about 0.8% of the total workforce in 2016.

The number of employees in *Accommodation, catering and hospitality* sector was around 200 thousand in 2009-2016. Between 2009 and 2014, a slight decrease occurred, and in 2015 and 2016, due to the overall economic recovery and the related growing demand for this type of services, the number of employees grew (Fig. 2.23). The number of secondary vocational education graduates in the fields of Gastronomy, hotel management and tourism decreased steadily between 2009 and 2016, from over 10 thousand in 2009 to approx. 6 thousand in 2016 (Fig. 2.24), with graduates with a CVE and graduates with A-levels participating in the decline

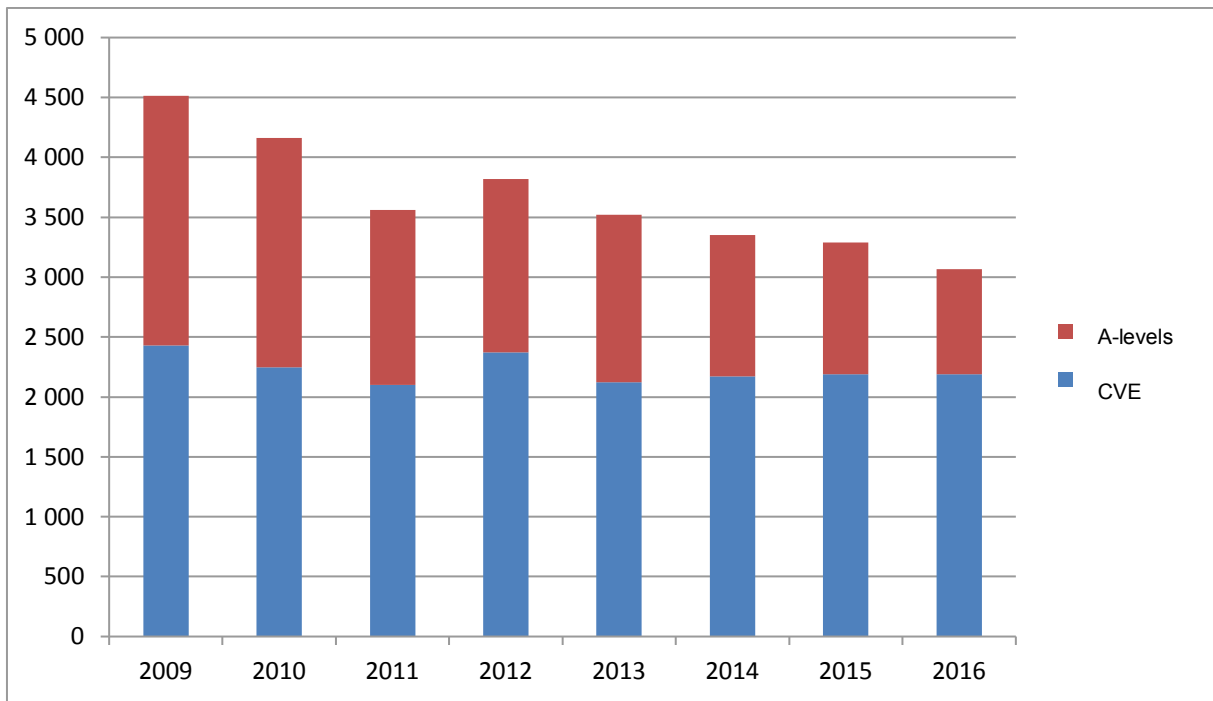
virtually evenly. In terms of labor reproduction, however, the number of graduates with secondary vocational education appears to be sufficient: although the ratio of the number of graduates to the total workforce has decreased from the initial 5% in 2009, it still remains at a sufficient 3% in 2016.

Fig. 2.19: Developments in the number of employees in Agriculture, forestry, fisheries, 2009-2016, Czech Republic



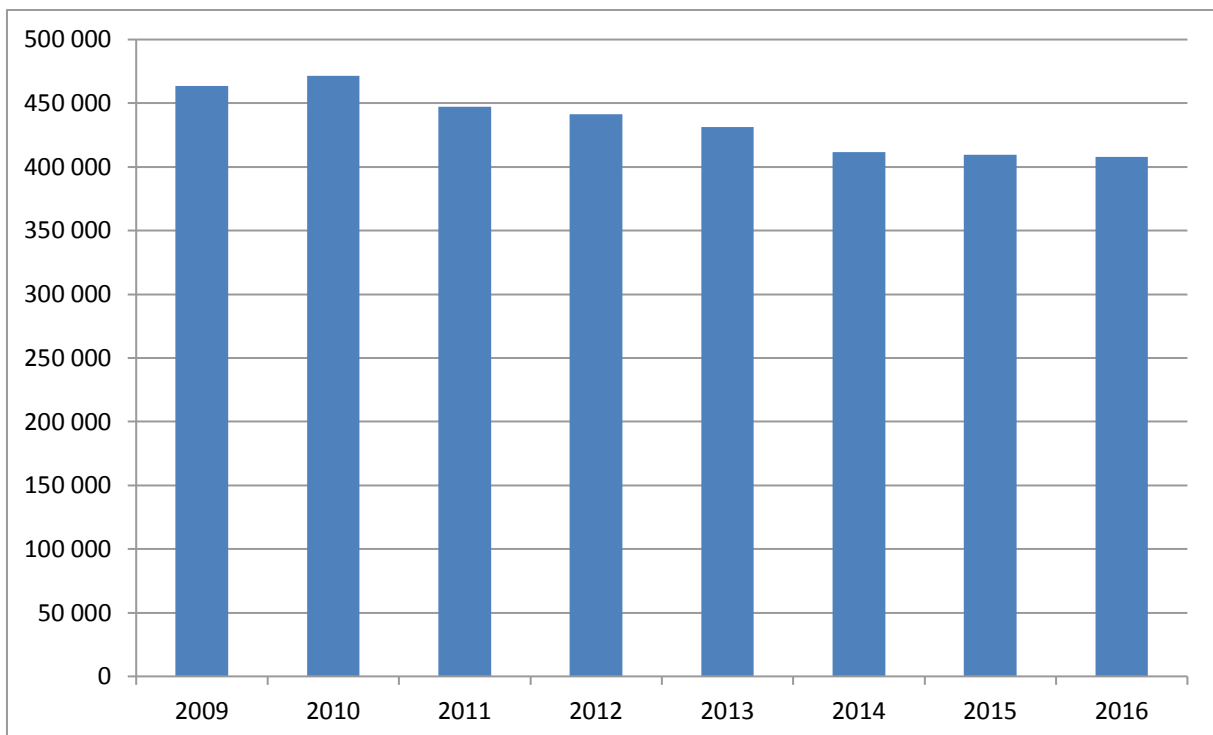
Source: Own figure created using Czech Bureau of Statistics data, GDP, national accounts - National Accounts Database

Fig. 2.20: Developments in the number of graduates with a CVE and A-levels in Agriculture and forestry, 2009-2016, Czech Republic



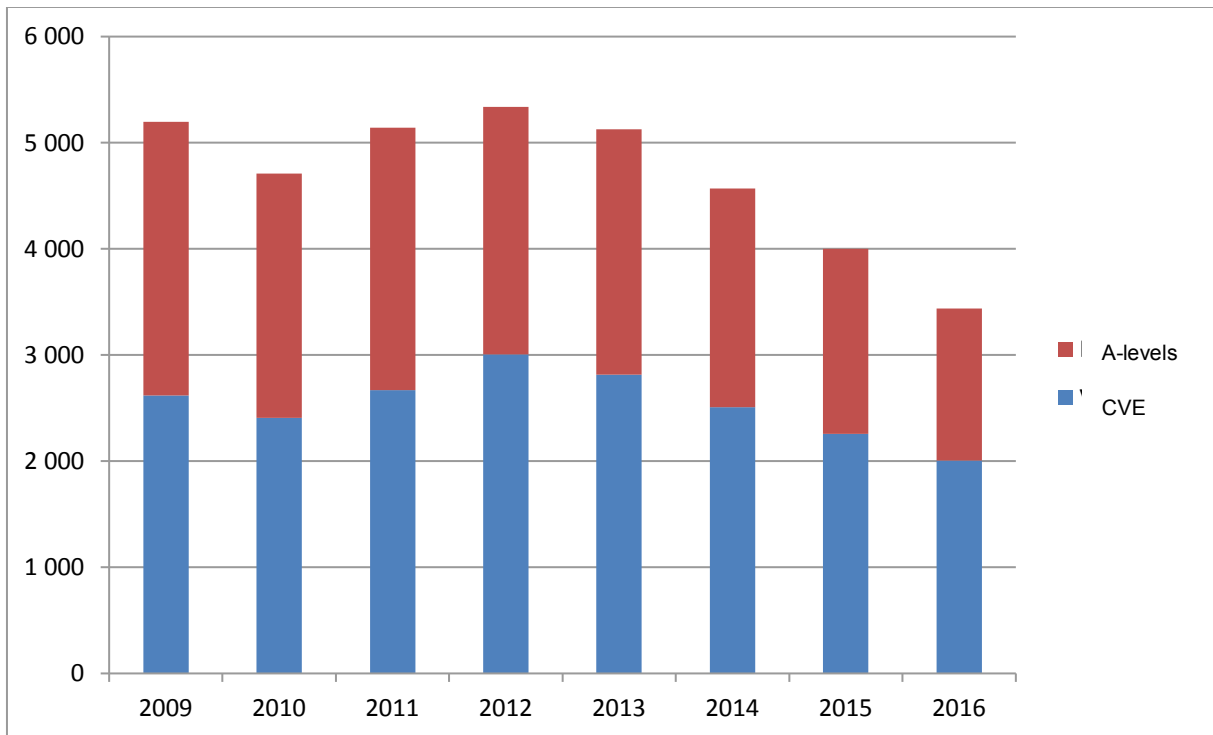
Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Fig. 2.21: Developments in the number of employees in Construction, 2009-2016, Czech Republic



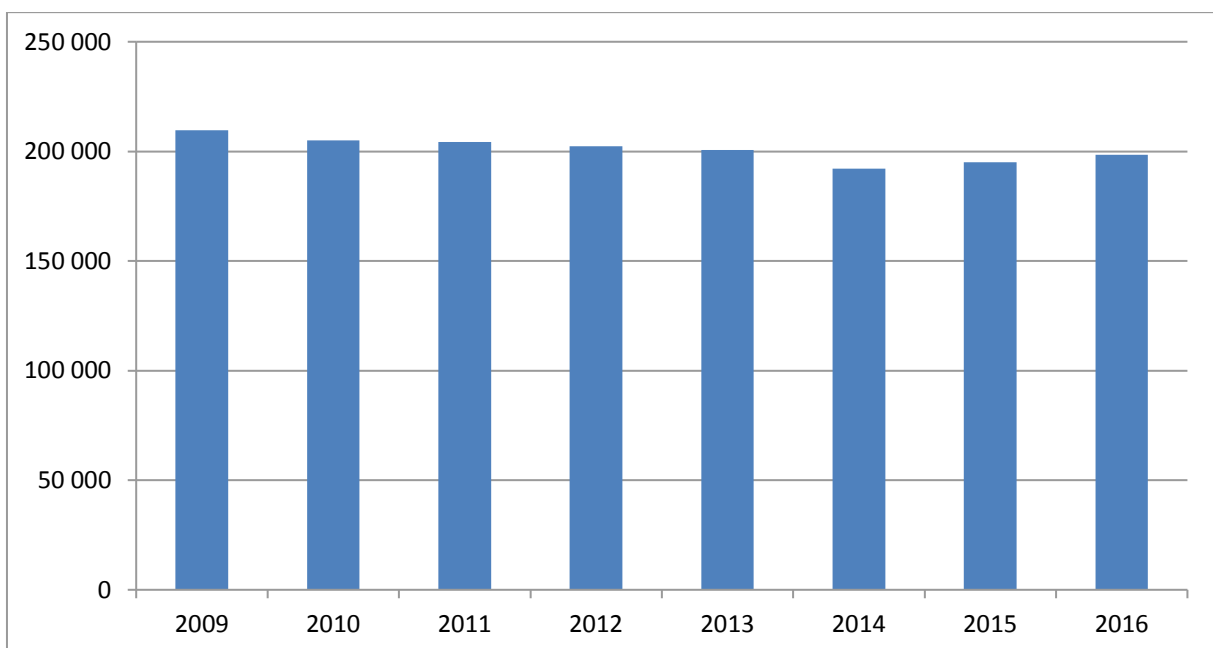
Source: Own figure created using Czech Bureau of Statistics data, GDP, national accounts - National Accounts Database

Fig. 2.22: Developments in the number of graduates with a CVE and A-levels in Construction, geodesy, cartography, 2009-2016, Czech Republic



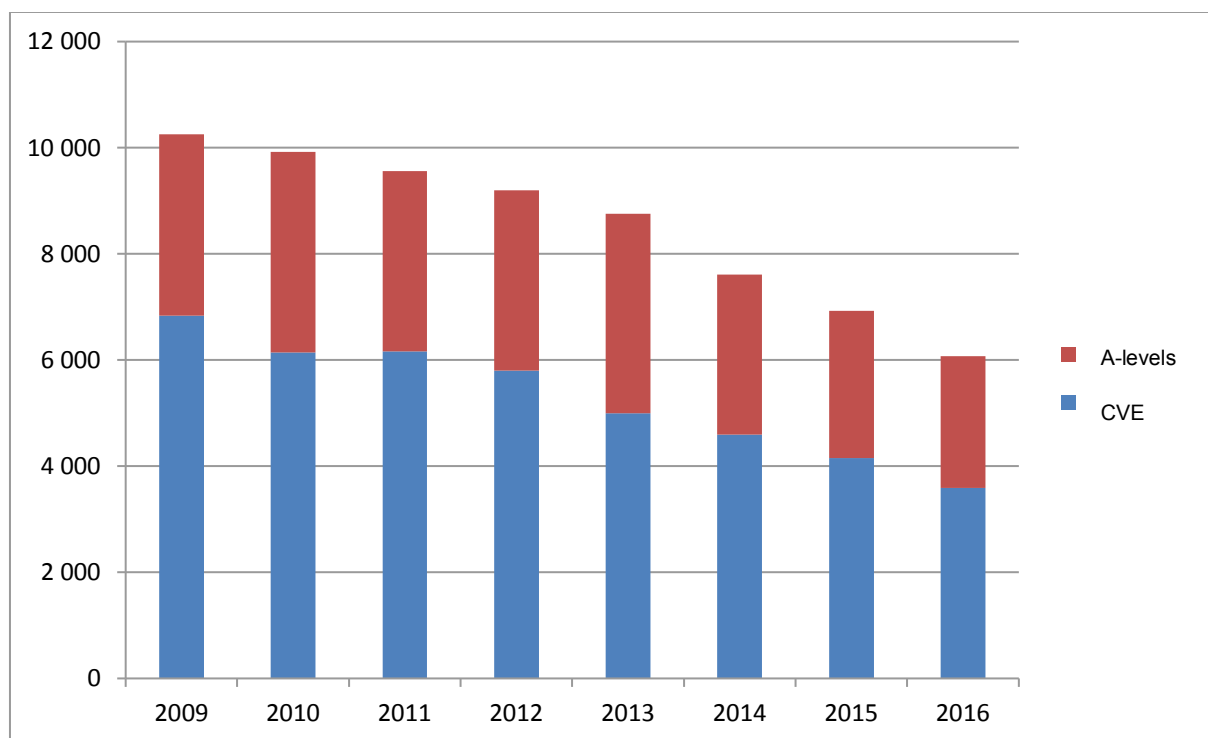
Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Fig. 2.23: Developments in the number of employees in Accommodation, catering and hospitality, 2009-2016, Czech Republic



Source: Own figure created using Czech Bureau of Statistics data, GDP, national accounts - National Accounts Database

Fig. 2.24: Developments in the number of graduates with a CVE and A-levels in Gastronomy, hotel management, tourism, 2009-2016, Czech Republic



Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

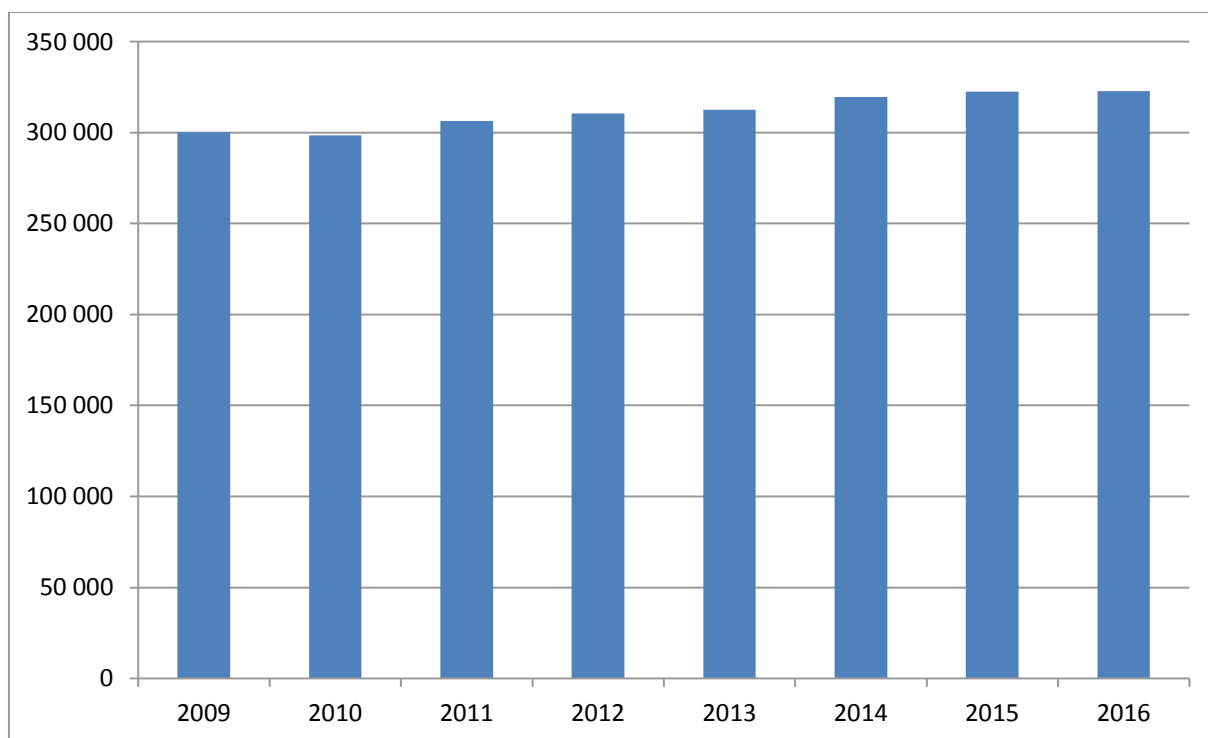
2.3 Health care and social services, education

Between 2009 and 2015, the number of workers in *Health care and social services* sector grew from approx. 300 thousand to approx. 320 thousand (Fig. 2.25). The growth in the number of workers is practically the same in all the relevant years, with a single exception, is unrelated to the evolution of the economic cycle, and it can be assumed that it is more related to population aging and the resultant growing demand for health care and social services. In 2016, the growth of the number of workers slowed down substantially; the reasons behind the slowdown would require a more in-depth analysis. The number of secondary vocational education graduates in *Health care* declined markedly between 2009 and 2011, and slightly between 2011 and 2016 (Fig. 2.26). We note opposing development trends in the individual segments of secondary vocational education. While the number of graduates with a CVE gradually grew, the number of graduates with A-levels decline, on the contrary.

The number of people working in the *Education* sector decreased in 2010 on year-on-year basis, and has been growing constantly in the following years, up to 2015, while in 2016, there was once again a slight year-on-year decline to just below 300 thousand (Fig. 2.27). The number of workers in education is therefore slightly lower than the number of workers in health care and social services. The number of secondary vocational education graduates in the fields of *Pedagogy, teacher training, social care* exhibited different development trends in individual years, alternating between growth and decline. While there were no graduates with a CVE until 2012, starting from 2013, they have been contributing to the overall increase in the number of graduates in these fields.

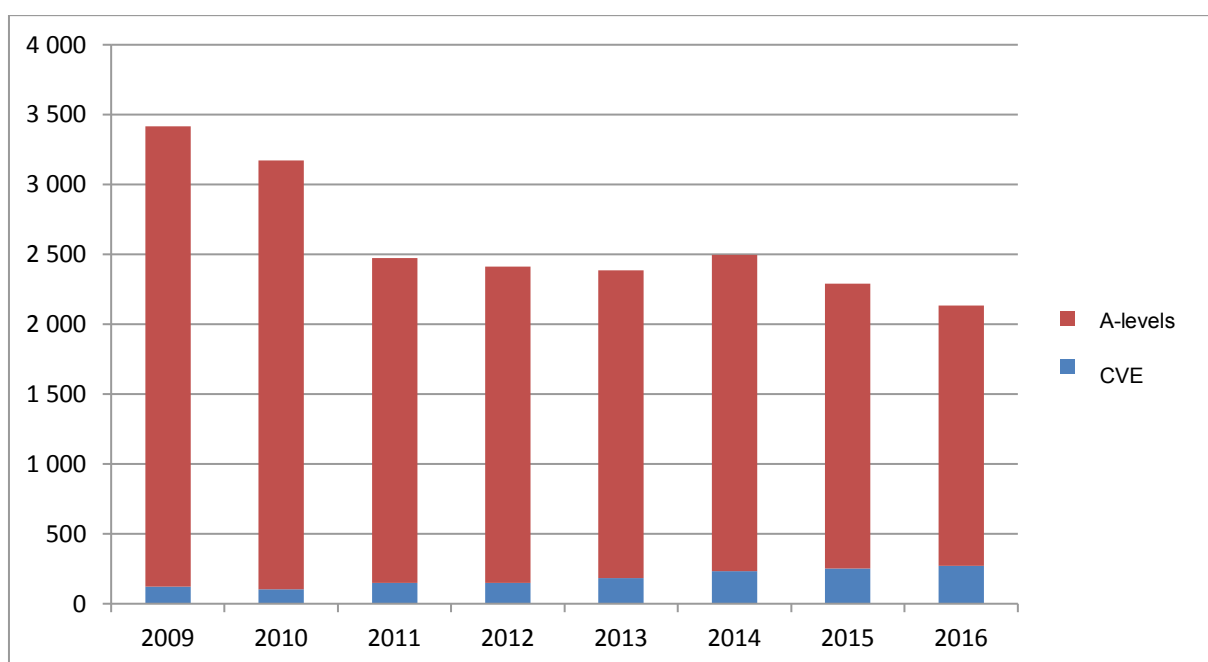
What makes the analysis of developments in the number of workers, the number of graduates and their mutual relationship in the fields of health care, social services and education more difficult is the fact that in terms of employment, social care falls under health care, but is a part of educational fields in school statistics. On the other hand, available data on the age structure of workers makes the analysis easier, as discussed in Chapter 4 of this study.

Fig. 2.25: Developments in the number of employees in Health care and social services, 2009-2016, Czech Republic



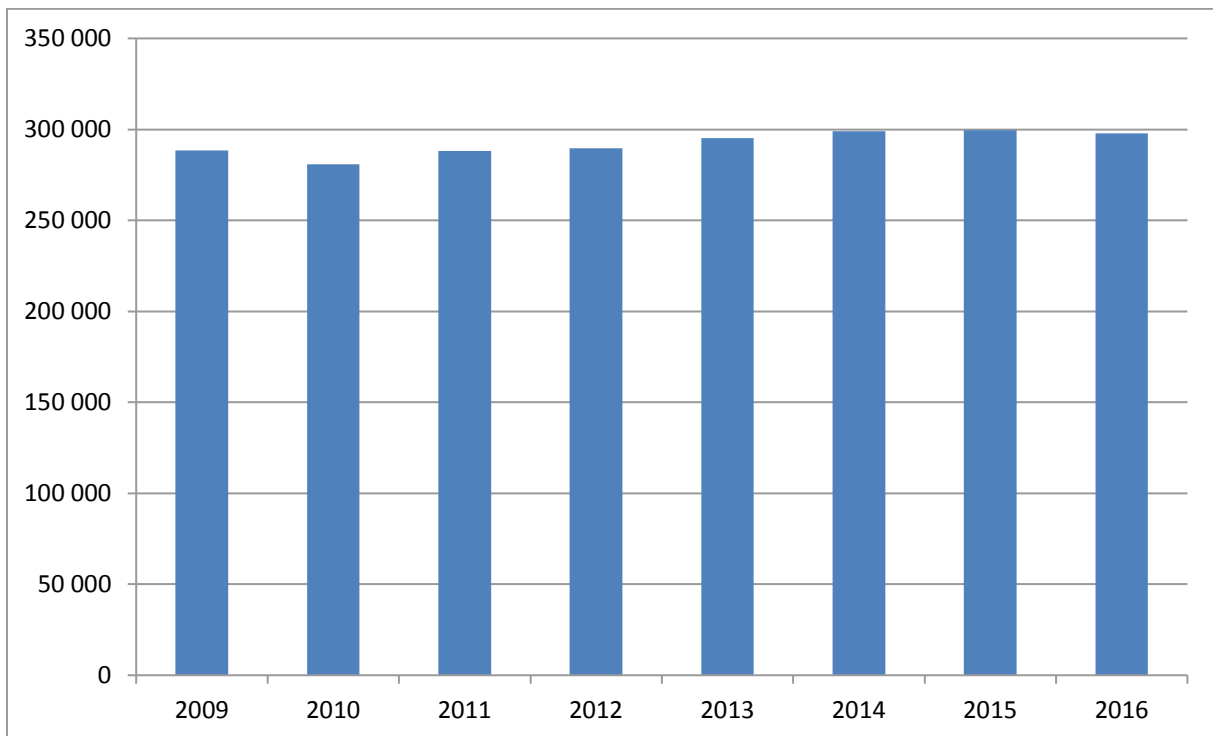
Source: Own figure created using Czech Bureau of Statistics data, GDP, national accounts - National Accounts Database

Fig. 2.26: Developments in the number of graduates with a CVE and A-levels in Health Care, 2009-2016, Czech Republic



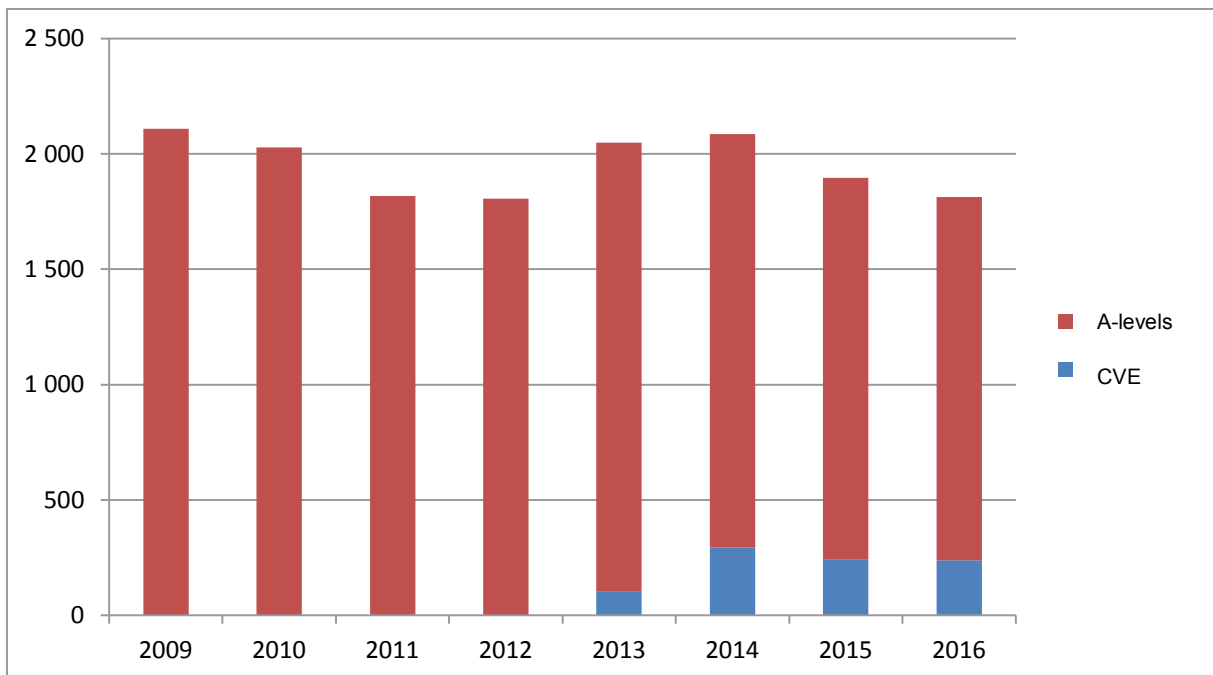
Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Fig. 2.27: Developments in the number of employees in Education, 2009-2016, Czech Republic



Source: Own figure created using Czech Bureau of Statistics data, GDP, national accounts - National Accounts Database

Fig. 2.28: Developments in the number of graduates with a CVE and A-levels in Pedagogy, teacher training, social care, 2009-2016, Czech Republic



Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

2.4 Comparison of developments across sectors

The previous findings, as presented in Sections 2.1 through 2.3, show that the number of workers in the different sectors is uneven, thus demonstrating structural changes in the economy in the sense of changes in the sectoral structure. They also show that developments in the number of graduates in individual fields is uneven, which testifies to structural changes in the system of education in the sense of a change in the disciplinary structure of graduates. And finally, they point to a highly uneven development of the relationship between the number of employees in individual sectors and the number of graduates in the relevant fields.

The aim of this section is to summarize the previous findings and to compare the development of the relationships outlined across individual sectors.

Fig. 2.29 shows the ratio of the number of secondary vocational education graduates in the individual fields to the total number of workers in the respective sectors. Let us reiterate that under the hypothetical assumption of an even age structure of workers, zero "migration" (i.e., a situation where solely the graduates in the respective fields of study of schools in the Czech Republic work in those sectors and do not work anywhere else), 40 years of work, and assuming that solely secondary school graduates work in those sectors, it is necessary to achieve a graduate ratio of approx. 2.5% to maintain reproduction of the workforce. The above assumptions are obviously hardly sustainable; however, they can provide some elementary guidance to reproducibility of the workforce. (As regards university graduates, the outcome does not change provided that such university graduates have previously completed secondary *vocational* education in the relevant field).

There is no sector in Fig. 2.29 where the ratio of the number of secondary vocational education graduates to the total number of employees would grow. This is due to overall developments in secondary vocational education where the numbers of graduates are dropping steadily (see Fig. 0.1).

A contrario, a significant decline occurred in the manufacture of textiles and clothing, wood processing fields and sectors, in accommodation, catering and hospitality. The growing demand for labor in the engineering and automotive industries is still not accompanied by the requisite increase in the number of secondary vocational education graduates, either. The largest decline can be seen in fields of study (sectors) that should play one of the key roles in the Industry 4.0 initiative, i.e., in electrical engineering, telecommunications and IT. Although the 3% ratio of

graduates to the total labor force is borderline sufficient, however, the negative trend of a growing demand for labor on the one hand, and the decline in the number of graduates on the other hand, cannot be overlooked. Many other fields of study have been below the simple reproduction limit for an extended period of time, which will bring either deterioration in the qualifications of the workforce, or the necessity of opening up the labor market in those sectors to workers from other countries to a greater extent.

Fig. 2.30 provides a look at the structure of the total number of secondary vocational education graduates in 2009-2016 by individual groups of fields. More than half of all graduates of secondary vocational schools (with CVEs, without A-levels) come from a mere five groups of disciplines. The most numerous groups of disciplines in terms of the number of graduates for 2009-2016 are *Engineering, mechanical engineering* and *Gastronomy, hotel management and tourism* (both with an equal share of the total number of graduates at 13%), followed by *Economics, administration* (11%), *Electrical engineering, telecommunications and computer science* (9%), and *General vocational training*.

Fig. 2.31 shows developments in the number of graduates in individual groups of disciplines between 2009 and 2016, and we can thus compare the rather significant changes in the structure of graduates that have occurred in the course of a mere seven years across sectors.

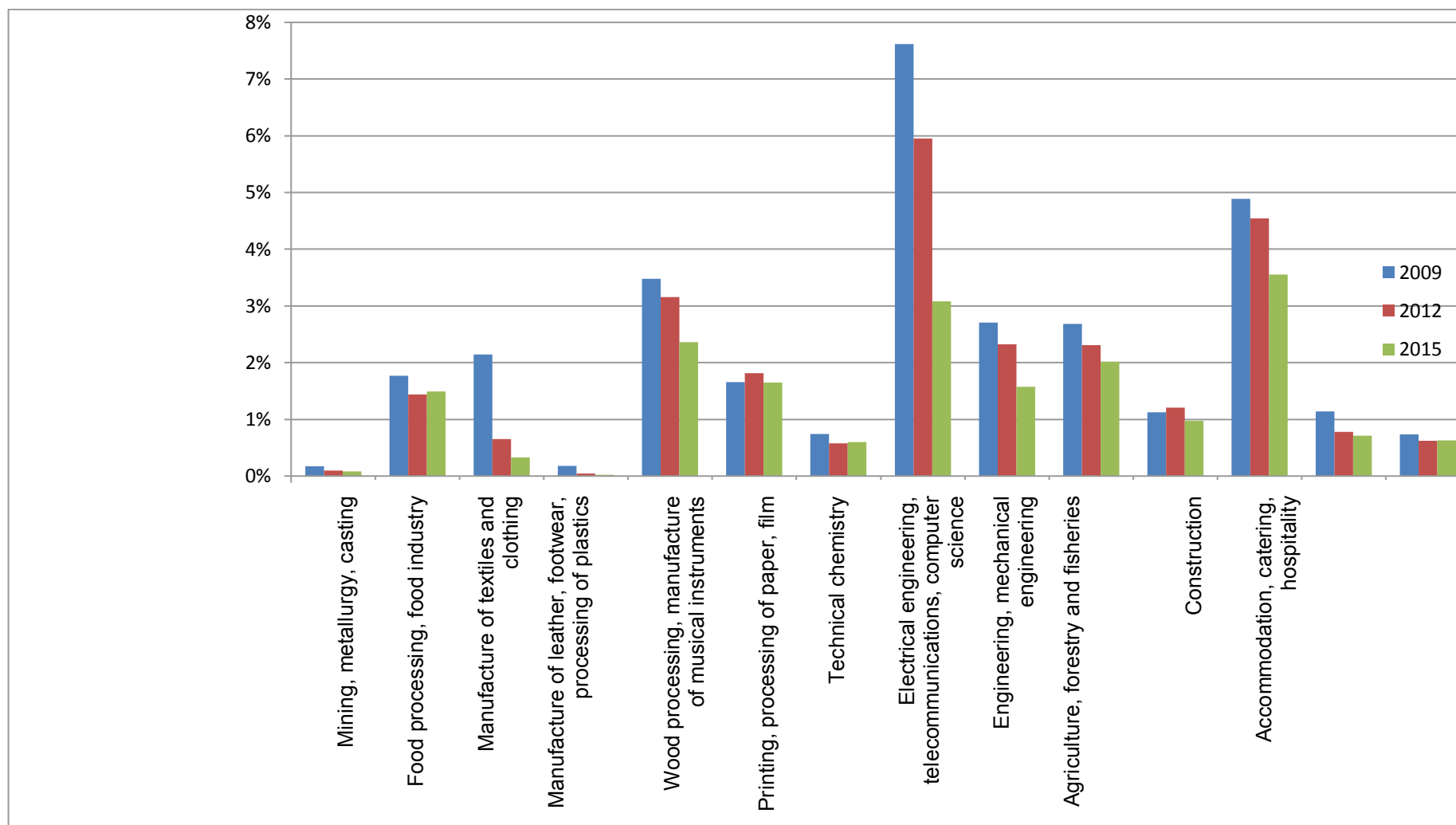
Given the overall trend of a marked decline in the number of graduates (Fig. 0.1), it is not surprising that the numbers of graduates in the various groups of disciplines are declining for most part; in some cases, the decline is significant. The sharpest decline can be seen in those groups of disciplines which are also the largest in terms of the number of graduates, i.e., in *Gastronomy, hotel management and tourism, Electrical engineering, telecommunications and computer science, Economics and administration* (2013 was a mere exception and did not disrupt the long-term downward trend), and finally, *Engineering, mechanical engineering*.

The other two most numerous groups of disciplines did not exhibit monotonous developments throughout the period under observation. The number of graduates increased in both *Construction, geodesy, cartography* and *Agriculture and forestry* in 2011 and 2012, which culmination was followed by a rather steep decline in the number of graduates in these disciplines.

Probably as a result of administrative changes in the secondary education system, graduates in the fields of *Business in sectors, industries* (where the number of graduates has dropped to zero since 2013) have been replaced in part with graduates in *Informatics* disciplines (with the first

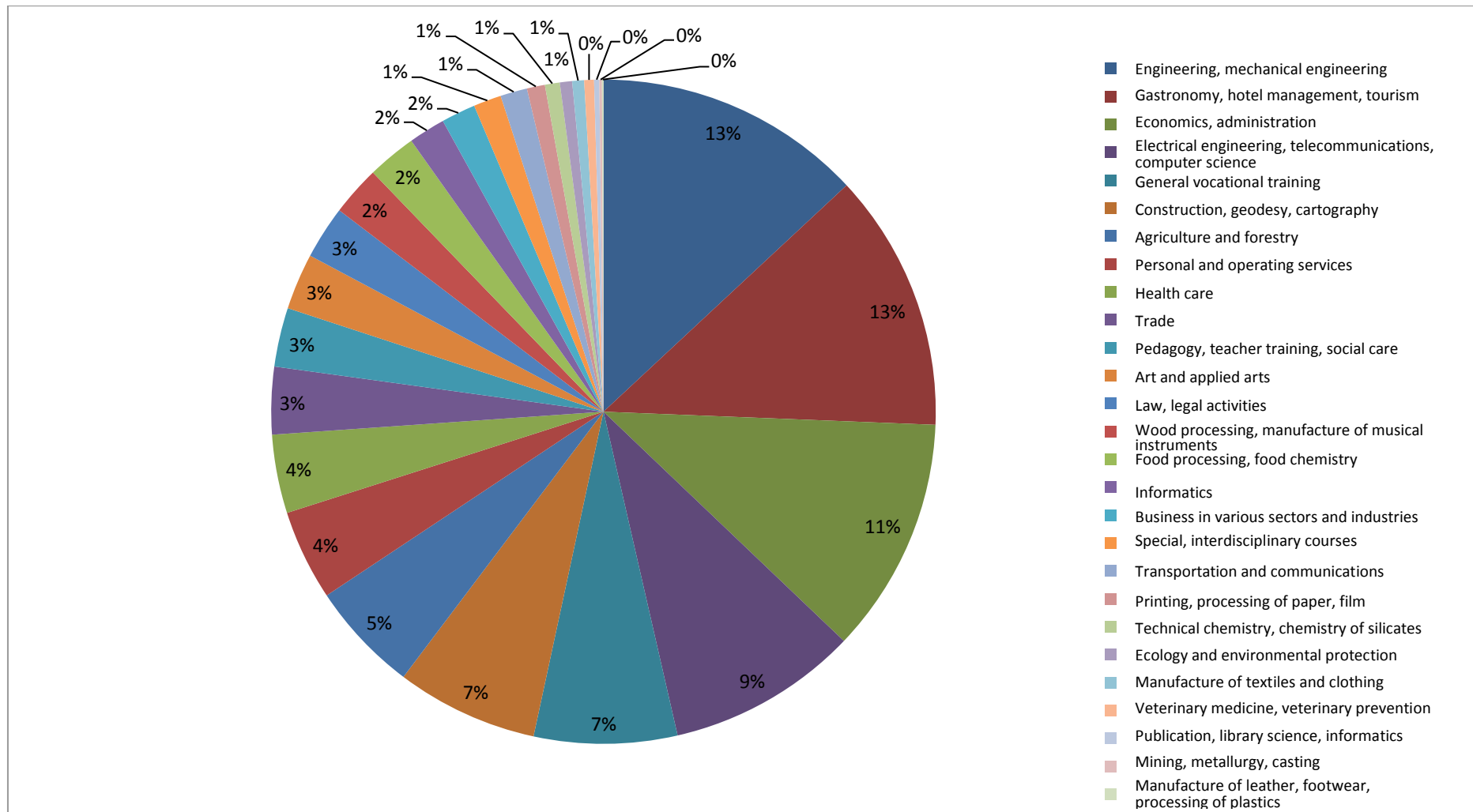
graduates in 2012; the number then continued growing up to 2014; however, there is year-on-year decline between 2015 and 2016 even in these disciplines, designed for the modern era).

Fig. 2.29: Ratio between numbers of graduates and employees in individual sectors, 2009, 2012, 2015, Czech Republic



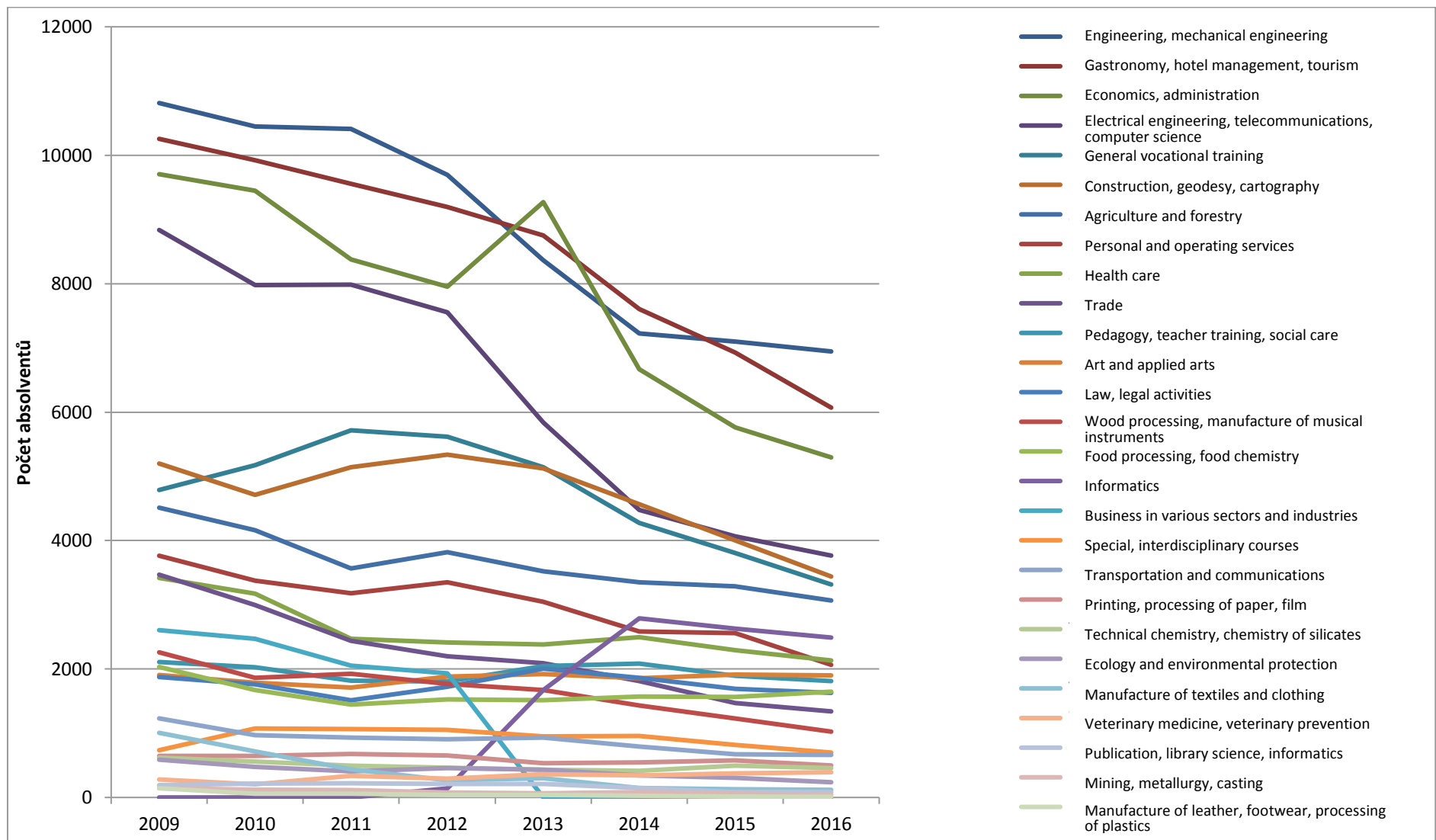
Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators, and Czech Bureau of Statistics, Industry, Energy sector - Economic results of industry

Fig. 2.30: Structure of secondary vocational education graduates (with a CVE and A-levels) in the Czech Republic in 2009-2016



Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Fig. 2.31: Development in absolute numbers of secondary vocational education graduates (with a CVE and A-levels) by disciplines, 2009-2016, Czech Republic



Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

We will end our comparison of the sectoral structure of secondary school graduates by looking at two tables summarizing developments in the number of graduates between 2009 and 2016.

The left part of Tab. 2.1 provides the absolute numbers of secondary vocational education graduates in individual groups of disciplines in 2009, and shares in the total number of secondary vocational education graduates in 2009, expressed in percentages. The right part is arranged in a similar fashion and captures absolute and relative numbers of secondary vocational education graduates for the year 2016. Both parts are arranged in descending order in order to express the ranking of individual groups of disciplines according to their share in the total number of graduates.

We note that while the absolute number of secondary vocational education graduates in the seven most important groups of disciplines was significant (see also Fig. 2.31), nevertheless, the ranking of the seven largest groups of disciplines did not change. Save for *Electrical engineering, telecommunications and computer science*, there has been no significant change in the share of graduates in the seven largest disciplines in the total number of graduates, either. However, it is precisely the development of the number and share of graduates in *Electrical engineering, telecommunications and computer science* that is a matter of concern with a view to the Industry 4.0 initiative. Not only did the total number of graduates drop by more than 5 thousand, i.e., by 57% (!), in the course of a mere seven years, but their share in the total number of secondary vocational education graduates has also declined, from approx. 11% in 2009 to approx. 7% in 2016. Therefore, there is nothing to suggest that secondary vocational education is prepared for the implementation of the Industry 4.0 initiative, as hitherto tendencies seem to suggest opposite.

Tab. 2.2 provides a final look on the change in the number of graduates in each group of disciplines: it captures absolute and relative changes in the number of graduates between 2009 and 2016. The individual groups of courses are ranked in descending order according to the absolute change in the number of graduates. The already mentioned *Electrical engineering, telecommunications and computer science* group is followed by *Economics and administration* (a 45% decrease), *Gastronomy, hotel management and tourism* (a 41% decrease) and *Engineering, mechanical engineering* (a 36% decrease).

Tab. 2.1: Number of vocational education graduates, absolute and relative numbers, 2009 and 2016, Czech Republic

2009			2016		
Title	absolute number	relative share	Title	absolute number	relative share
Engineering, mechanical engineering	10,813	13%	Engineering, mechanical engineering	6,945	14%
Gastronomy, hotel management, tourism	10,255	12%	Gastronomy, hotel management, tourism	6,070	12%
Economics, administration	9,705	12%	Economics, administration	5,295	10%
Electrical engineering, telecommunications, computer science	8,836	11%	Electrical engineering, telecommunications, computer science	3,766	7%
Construction, geodesy, cartography	5,199	6%	Construction, geodesy, cartography	3,440	7%
General vocational training	4,790	6%	General vocational training	3,316	6%
Agriculture and forestry	4,512	5%	Agriculture and forestry	3,067	6%
Personal and operating services	3,764	5%	Informatics	2,488	5%
Trade	3,469	4%	Health care	2,133	4%
Health care	3,418	4%	Personal and operating services	2,065	4%
Business in various sectors and industries	2,605	3%	Art and applied arts	1,899	4%
Wood processing, manufacture of musical instruments	2,260	3%	Pedagogy, teacher training, social care	1,814	4%
Pedagogy, teacher training, social care	2,109	3%	Food processing, food chemistry	1,645	3%
Food processing, food chemistry	2,032	2%	Law, legal activities	1,626	3%
Art and applied arts	1,910	2%	Trade	1,340	3%
Law, legal activities	1,875	2%	Wood processing, manufacture of musical instruments	1,025	2%
Transportation and communications	1,231	1%	Special, interdisciplinary courses	699	1%
Manufacture of textiles and clothing	1,006	1%	Transportation and communications	662	1%

Special, interdisciplinary courses	737	1%	Printing, processing of paper, film	498	1%
Printing, processing of paper, film	645	1%	Technical chemistry, chemistry of silicates	456	1%
Technical chemistry, chemistry of silicates	620	1%	Veterinary medicine, veterinary prevention	393	1%
Ecology and environmental protection	588	1%	Ecology and environmental protection	237	0%
Veterinary medicine, veterinary prevention	277	0%	Manufacture of textiles and clothing	119	0%
Publication, library science, informatics	194	0%	Publication, library science, informatics	84	0%
Mining, metallurgy, casting	144	0%	Mining, metallurgy, casting	43	0%
Manufacture of leather, footwear, processing of plastics	144	0%	Manufacture of leather, footwear, processing of plastics	11	0%
Informatics	0	0%	Business in various sectors and industries	0	0%

Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Tab. 2.2: Number of vocational education graduates, absolute and relative numbers, 2009 and 2016, Czech Republic

Field of study	Developments in 2009-2016	
	Absolute change of number of graduates in 2016 as compared to 2009	Number of graduates in 2016 relative to number of graduates in 2009 (2009 = 100 %)
Electrical engineering, telecommunications, computer science	-5,070	43%
Economics, administration	-4,410	55%
Gastronomy, hotel management, tourism	-4,185	59%
Engineering, mechanical engineering	-3,868	64%
Business in various sectors and industries	-2,605	0%
Trade	-2,129	39%
Construction, geodesy, cartography	-1,759	66%
Personal and operating services	-1,699	55%
General vocational training	-1,474	69%
Agriculture and forestry	-1,445	68%
Health care	-1,285	62%
Wood processing, manufacture of musical instruments	-1,235	45%
Manufacture of textiles and clothing	-887	12%
Transportation and communications	-569	54%
Food processing, food chemistry	-387	81%
Ecology and environmental protection	-351	40%
Pedagogy, teacher training, social care	-295	86%
Law, legal activities	-249	87%
Technical chemistry, chemistry of silicates	-164	74%
Printing, processing of paper, film	-147	77%
Manufacture of leather, footwear, processing of plastics	-133	8%
Publication, library science, informatics	-110	43%
Mining, metallurgy, casting	-101	30%
Special, interdisciplinary courses	-38	95%
Art and applied arts	-11	99%
Veterinary medicine, veterinary prevention	116	142%
Informatics	2488	N.A.

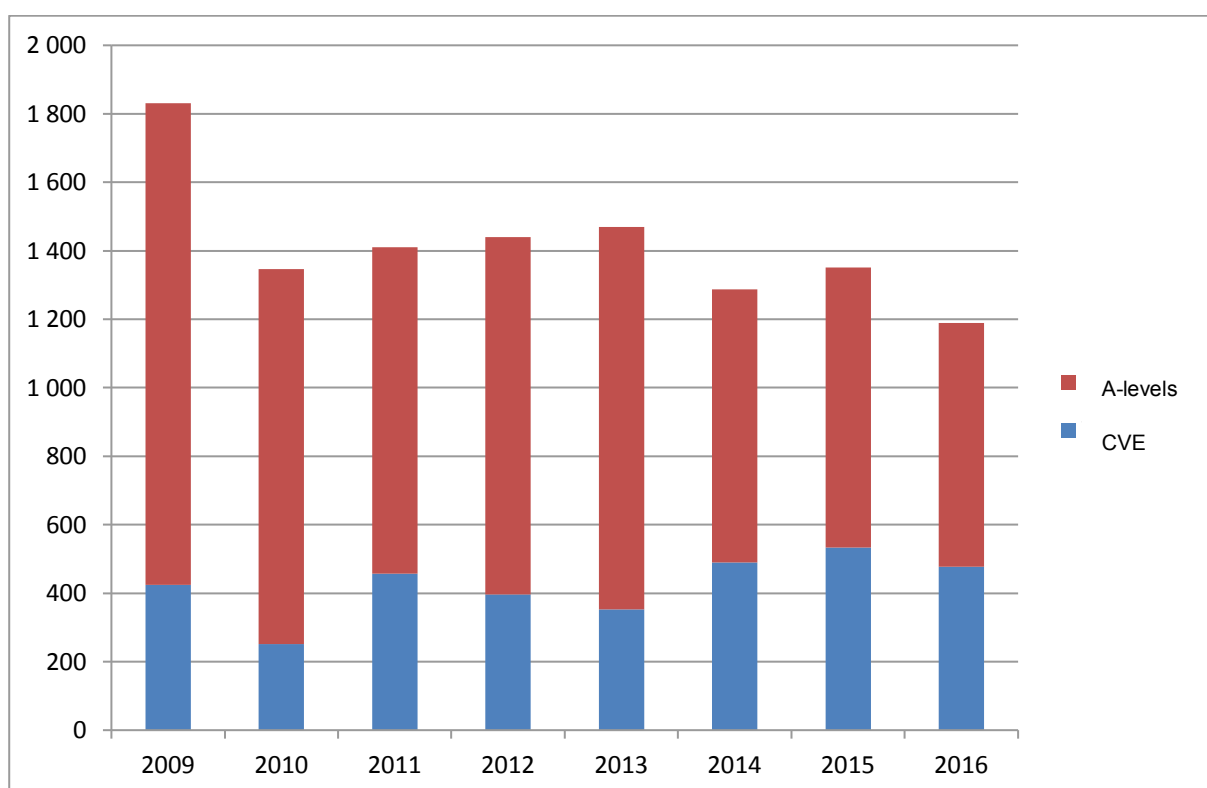
Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

2.5 Annex 1: graduates of other forms of secondary education

As regards secondary education, it is further possible to obtain education using forms of education other than intramural study. These are collectively referred to as "other forms" of education, and most often include extra-mural form of study.

Approximately 1,200 persons per year graduate from other forms of secondary vocational education, whether with a CVE or A-levels. However, the numbers of graduates have been declining over time, as shown in Fig. 2.32. The decline is particularly obvious in courses ending with A-levels, where the number gradually dropped from 1,400 in 2009 to 700 in 2016. The number of graduates from courses ending with a CVE is either constant or exhibits a slight increase, with less than 500 graduates per year.

Fig. 2.32: Developments in absolute numbers of graduates from other forms of secondary vocational education (with a CVE and A-levels) by disciplines, 2009-2016, Czech Republic



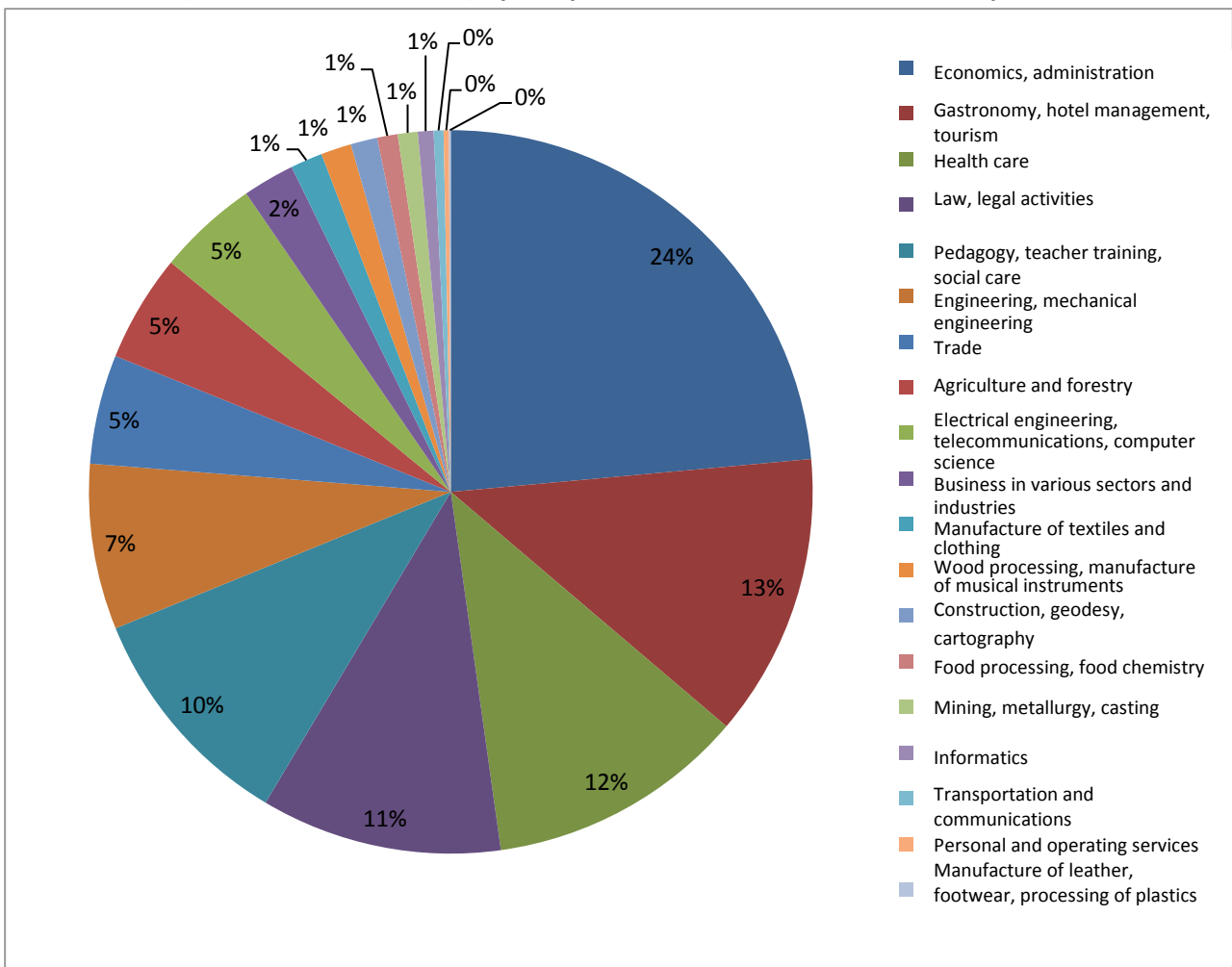
Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

The structure of graduates from other forms of secondary vocational education, broken down by disciplines (Fig. 2.33), differs from intramural study (Fig. 2.30). The following groups of disciplines account for the highest numbers of graduates: Economics, administration (24 %), Gastronomy, hotel

management, tourism (13%), Health care (12%), Law, legal activities (11%), Pedagogy, teacher training, social care (10%) and Engineering, mechanical engineering (7 %). Save for Gastronomy, hotel management, tourism, which has the same shares of graduates among both intramural and extramural students, the structure differs significantly.

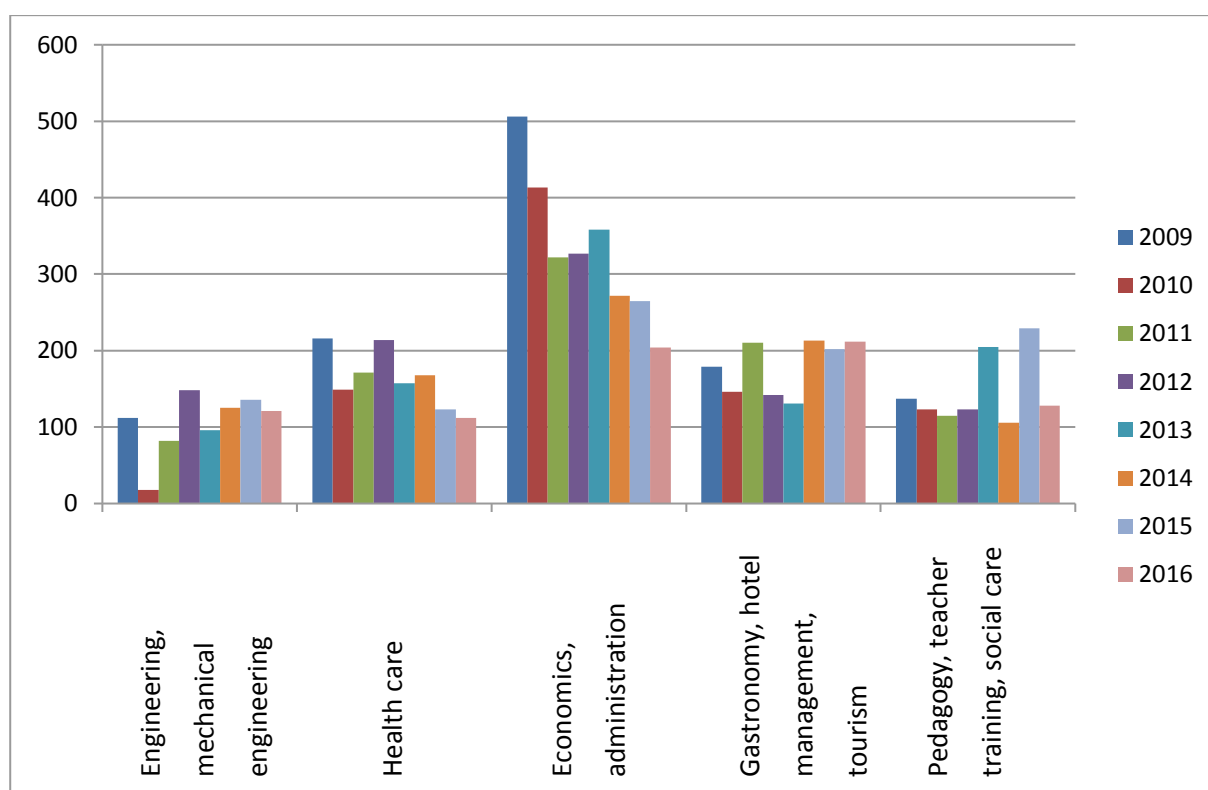
Further, the developments in the number of graduates from other forms of secondary vocational education in 2009-2016 exhibit different trends as compared to intramural form of education. Selected courses (with more than 100 graduates per year) are presented in Fig. 2.34. which clearly shows a marked drop in the number of graduated in Economics and administration. The number of graduates in other courses is more or less constant.

Fig. 2.33: Structure of graduates from other forms of secondary vocational education (with a CVE and A-levels) by disciplines, sum for 2009-2016, Czech Republic



Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Fig. 2.34: Developments in numbers of graduates from other forms of secondary vocational education (with a CVE and A-levels), selected disciplines, 2009-2016, Czech Republic



Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

Although the number of graduates from other forms of secondary vocational education, with the exception of graduates in Economic and administration, remains more or less constant, it cannot be said that this fact is capable of challenging the above conclusions: the number of graduates from other forms of secondary vocational education constitutes only a fraction of the number of intramural study graduates.

Between 2009 and 2016, over 11 thousand people graduated from other forms of secondary vocational education, while the number of intramural secondary vocational education graduates was over 550 thousand. The share of graduates from other forms of secondary vocational education thus accounts for less than 2%. In some fields of study, this form may mean a significant increase of the number of graduates (for instance, nearly a half of the graduates in Mining, metallurgy, casting completes their studies in other forms of study), but it certainly cannot be said that other forms of study constitute a proper substitute of declining and low numbers of graduates in intramural form of study.

Tab. 2.3: Share of graduates from other forms of secondary vocational education in the total number of secondary vocational education graduates in 2016, Czech Republic

Mining, metallurgy, casting	46%
Pedagogy, teacher training, social care	7%
Health care	5%
Law, legal activities	4%
Manufacture of textiles and clothing	4%
Economics, administration	4%
Trade	4%
Gastronomy, hotel management, tourism	3%
Agriculture and forestry	3%
Electrical engineering, telecommunications, computer science	2%
Engineering, mechanical engineering	2%
Transportation and communications	2%
Wood processing, manufacture of musical instruments	1%
Food processing, food chemistry	1%
Informatics	1%
Personal and operating services	1%

Source: Own figure created using Ministry of Education data, Statistical Yearbook of Education - performance indicators

2.6 Annex 2: University graduates

This deals primarily with secondary vocational education graduates as they are a key source of labor in most sectors (whether they enter the labor market directly after graduating from secondary school, or continue their studies in the same or related field in an extended course, at a higher vocational school or at university). This annex of sorts to this chapter which compares employment in individual sectors of the national economy with the number of secondary vocational school graduates in individual fields of study offers a brief look at the structure of university graduates. We do dwell on them in more detail because publicly available statistics of the Ministry of Education, Youth and Sports only offer data on the number of graduates segmented by groups of disciplines with a relatively high (gross) degree of aggregation.

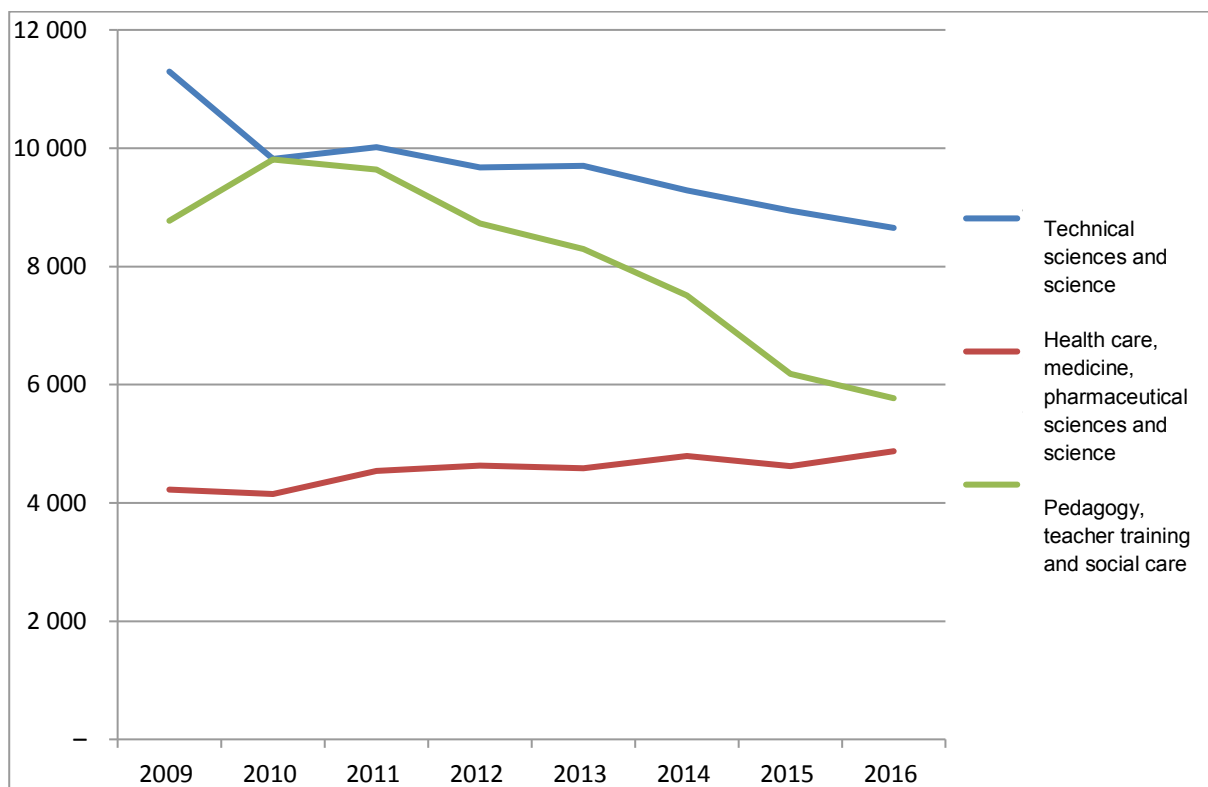
Fig. 2.35 deals with those groups of disciplines whose graduates are completely indispensable in the labor market in the relevant sectors, i.e., groups of disciplines preparing university-educated technicians, physicians, pharmacists or teachers. These three groups exhibit different developments. While the number of university graduates in health care, medical and pharmaceutical fields has been growing slightly in 2009-2016, there has been a moderate decline in technical sciences and science.

A significant decrease, undoubtedly related to the unfortunate situation concerning remuneration of primary and secondary school teachers, and by extension, the low and ever diminishing attractiveness of the teaching profession, can be seen in the fields of Pedagogy, teacher training and social work. Between 2010 and 2016, the number of graduates in these disciplines fell by more than 40%.

Fig. 2.36 brings an overall view of the structure of university graduates in 2009-2016, broken down by individual groups of disciplines. While the share of the two best represented groups, i.e., economic and technical disciplines, in the total number of graduates has declined, the share of graduates in humanities and social sciences has grown (in the classification used by the ministry for statistical purposes, graduates in economic disciplines are already excluded).

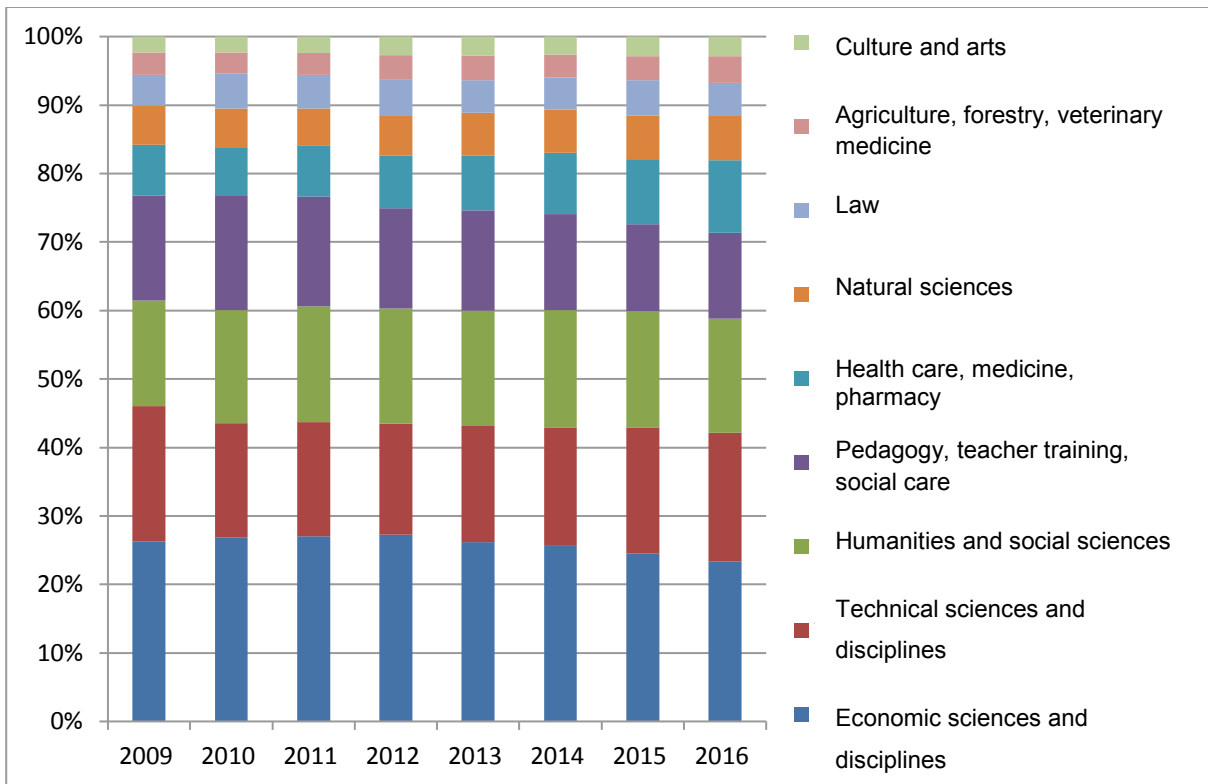
Fig. 2.36 further shows that the number of graduates in teacher training disciplines has been declining both in absolute and relative terms, in relation to the total number of graduates, while the share of graduates in legal disciplines has been growing.

Fig. 2.35: Developments in the number of university graduates in Technical sciences and science, Health care, medicine, pharmaceutical sciences and science, Pedagogy, teacher training and social care, 2009-2016, Czech Republic



Source: Own figure created using Ministry of Education data, Data on students, first-time enrolled university students and graduates

Fig. 2.36: Structure of university graduates (Bachelor's, Master's programs) broken down by groups of disciplines, 2009-2016, Czech Republic



Source: Own figure created using Ministry of Education data, Data on students, first-time enrolled university students and graduates

3. Developments in work productivity in the Czech Republic in 2009-2016

Chapter 3 of our study is devoted to a brief analysis of developments in work productivity in the Czech Republic in 2009-2016. Generally speaking, work productivity means the relationship between economic output on the one hand, and the input of labor as a factor of production on the other hand. As we follow work productivity at the level of individual sectors of the national economy (on "mezzo" level), gross added value is the most appropriate output indicator; we have already dealt with gross added value in detail in Chapter 1.

While the choice of the output indicator is rather clear at sectoral level, the situation is somewhat more complicated when it comes to the labor input. Labor input can be characterized in three different ways at sectoral level: as the number of persons employed (physical number of persons employed), the number of persons employed recalculated to full time (the English abbreviation for Full Time Equivalents, FTE, is sometimes used), or the number of hours worked. There are advantages and disadvantages to the individual indicators. Hours worked is the least accurate indicator (by definition, when estimated, greater errors occur in the estimate than with the number of persons employed), on the other hand, this indicator describes the phenomenon under examination in the most relevant way, as it captures the actual involvement of labor most aptly. It needs to be noted that sectoral analyses need to work with the number of persons employed, rather than the number of employees, as self-employed persons also contribute to the added value of the sector.

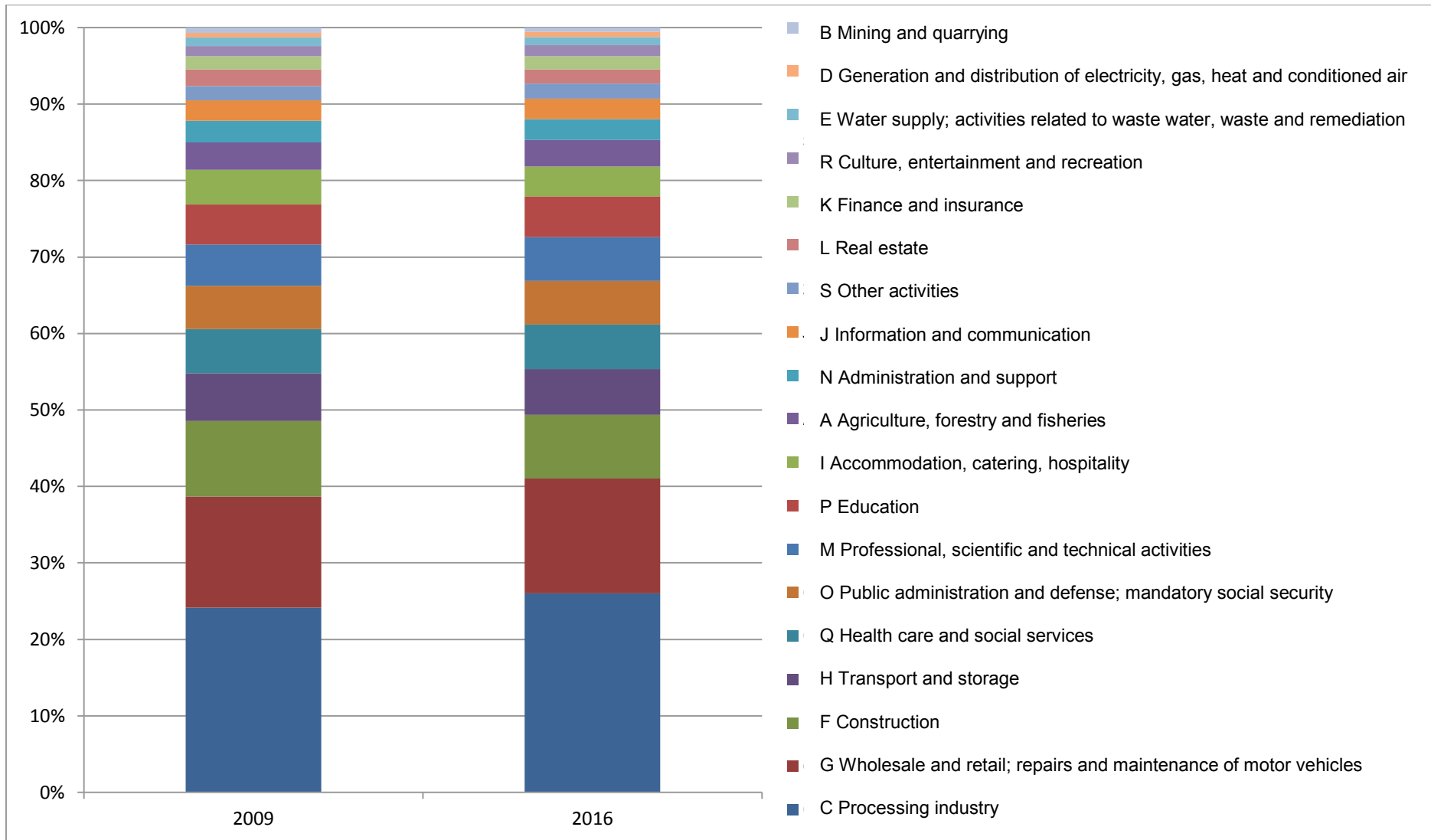
Following to three different definitions of employment, we can construct three types of work productivity indicators. Work productivity can be expressed as the volume of gross added value per employed person, as the volume of gross added value per FTE, or the volume of gross added value per hour worked. In light of our assessment of the relevance of indicators, we favor using the number of hours worked, and work with this indicator hereinafter. (By the way, a different application of these indicators leads to different results in comparison of work productivity between EU member states and the United States; while hourly work productivity is roughly comparable, productive of work per person employed is significantly higher in the USA due to the higher number of hours worked per worker.)

Fig. 3.1 shows the structure of the number of hours worked in the national economy and its developments between 2009 and 2016. The manufacturing industry accounts for the largest share of

the total hours worked, and the importance of this sector had increased even further in terms of hours worked between 2009 and 2016 to approx. 27% in 2016. The second most important sector, wholesale and retail trade, and repair and maintenance of motor vehicles, accounted for approx. 15% of the number of hours worked in both years under review. *A contrario*, the importance of the third largest sector, the construction industry, decreased by about three percentage points during the seven years in question; the decrease in the number of persons employed in this sector was nevertheless clearly evident from our analysis presented in the previous chapter. The total share of the three largest industries in the total number of hours worked reached nearly 50%.

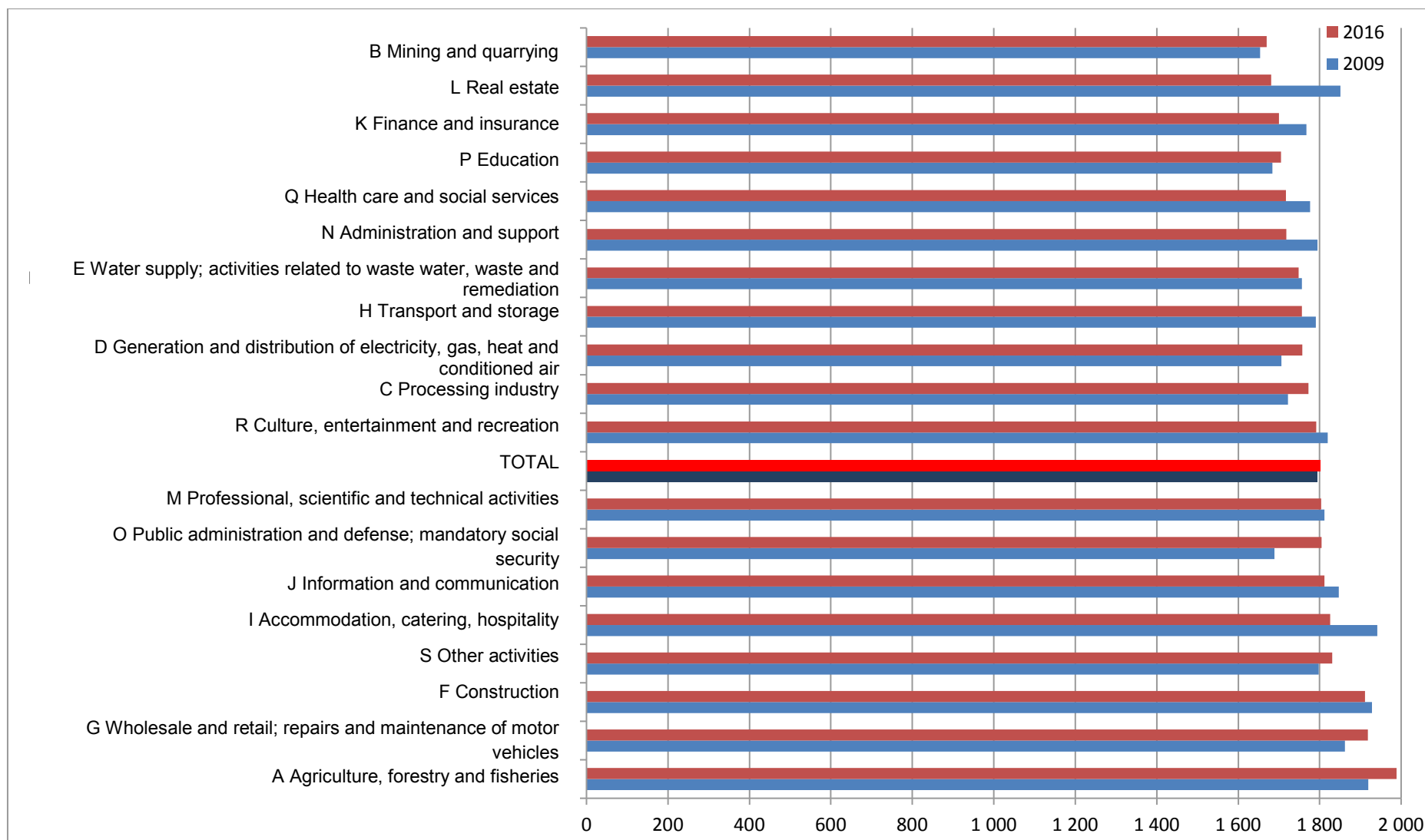
Fig. 3.2 supports our earlier consideration as to whether it is appropriate to express work productivity by the number of hours worked, rather than by the number of persons employed. Fig. 3.2 shows the differences in the average number of hours worked per one full-time equivalent. While the average number of hours worked was around 1,800 hours per year per full-time equivalent in 2009-2016, it reached almost 2,000 hours in the agricultural sector in 2016, and only 1,670 hours in the mining and quarrying sector. Fig. 3.2 also shows developments in the average number of hours worked per full-time equivalent between 2009 and 2016. The average number of hours worked for the whole economy increased only slightly (from 1,793 hours in 2009 to 1,802 hours in 2016, respectively, i.e. by 0.5% in the course of seven years), but the developments in individual sectors differed. In the already mentioned agriculture and forestry sector, the number of hours worked increased by 3.6%, in trade, maintenance and repairs of motor vehicles, by 3.1%, in the manufacturing sector, by 3.0%. On the other hand, in the real estate sector, the average number of hours worked per full-time equivalent dropped by 9.2%, in administrative and auxiliary activities, by 4.2%, and in finance and insurance, by 3.8%. While changes in the utilization of labor would merit a more in-depth analysis (in particular using detailed data from structural payroll statistics broken down by job nomenclature categories), the obvious hypothesis is that while in sectors employing mostly manual workers, the average the number of hours worked by such workers grew, and in sectors employing other employees, the average number of hours worked per employee declined.

Fig. 3.1: Structure of the numbers of hours worked in national economy, 2009 and 2016, Czech Republic



Source: Own figure created using Czech Bureau of Statistics data, GDP, national accounts - National Accounts Database

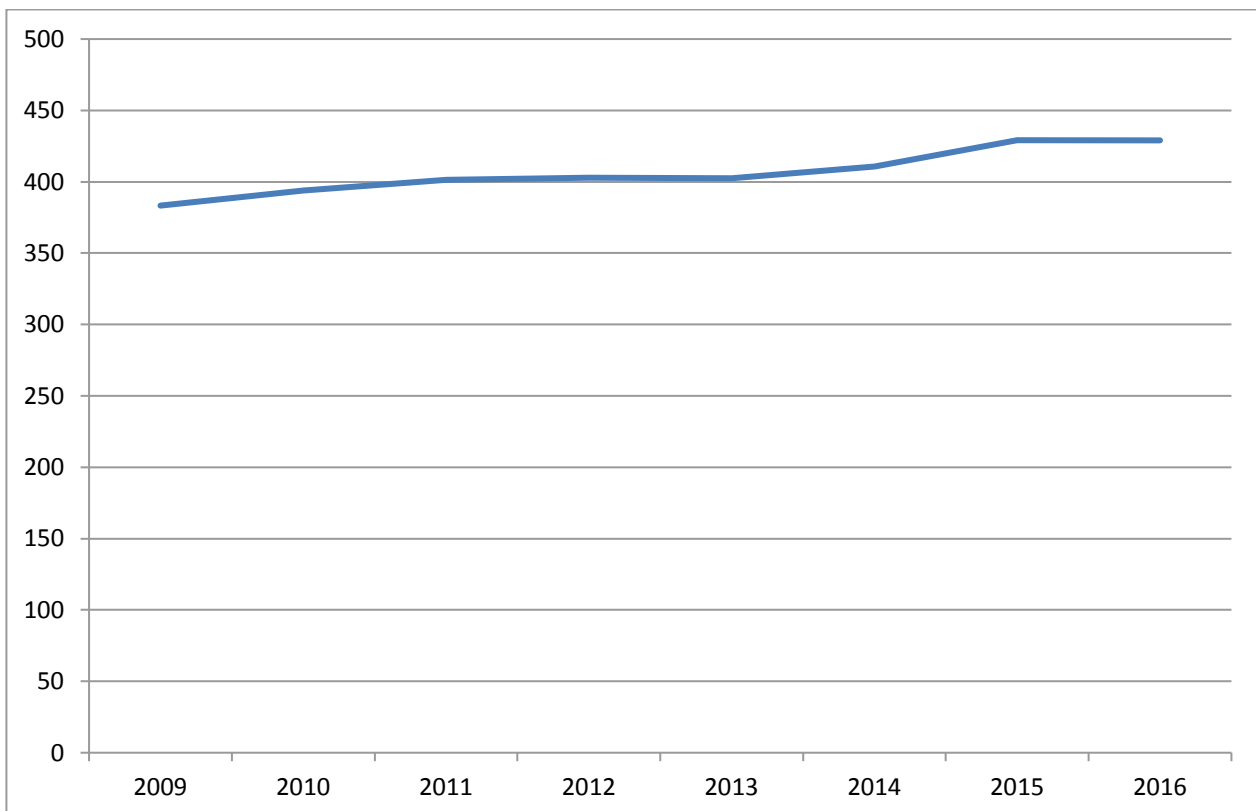
Fig. 3.2: Average number of hours worked in individual sectors of national economy per worker (full time), 2009 and 2016, Czech Republic



Source: Own figure created using Czech Bureau of Statistics data, GDP, national accounts - National Accounts Database

Fig. 3.3 captures developments in average work productivity in 2009-2016 for the entire national economy, expressed as the ratio of gross added value at constant prices to the number of hours worked. We can observe two phases of productivity growth (2009-2011 and 2013-2015), and two phases of stagnation (2011-2013 and 2015-2016). While the first phase of stagnation of work productivity per hour worked related to lower performance of the economy in the relevant years, we can see that contrary to that, in 2016, the growth of gross added value (and by extension, the growth of GDP) was not longer driven by increased utilization of labor, but instead by the utilization of a greater quantity of labor (increased employment). In 2016 hourly productivity reached CZK 429 per hour worked, and it needs to be reiterated that when the construction of the GDP indicator is viewed from the perspective of revenue (generation, distribution and application of revenue), revenue from labor as a factor or work (i.e., super-gross wage (gross wage including statutory employer's deductions), as well as all revenues from capital as a factor or work, both debt (interest paid and similar payments) and equity (dividends, shares in profit, etc.).

Fig. 3.3: Developments in work productivity values (GAV/hours worked) for the entire national economy, 2009-2016, Czech Republic



Source: Own figure created using Czech Bureau of Statistics data, GDP, national accounts - National Accounts Database

In this part, we will submit selected work productivity factors to analytical examination. From our point of view, decomposition into the impact of changes in work productivity in individual sectors (i.e., how hourly work productivity in each sector has changed) and into the impact of changes in sectoral structure of the economy (i.e., how the structure of hours worked has changed) is an important type of decomposition of overall development of work productivity per hour worked.

The impact of changes in work productivity in individual sectors is calculated using the following formula:

$$\Delta_{SS}^{(OH_0)} = \frac{\sum_{i=1}^n pp_{1,i} OH_{0,i}}{\sum_{i=1}^n OH_{0,i}} / \frac{\sum_{i=1}^n pp_{0,i} OH_{0,i}}{\sum_{i=1}^n OH_{0,i}}, \quad (3.1)$$

where $pp_{1,i}$ is work productivity in sector i during period 1,

$pp_{0,i}$ is work productivity in sector i during period 0, and

$OH_{0,i}$ is the number of hours worked in sector i during period 0.

The impact of changes in the number of hours worked is calculated using the following formula:

$$\Delta_{STR}^{(pp_1)} = \frac{\sum_{i=1}^n pp_{1,i} OH_{1,i}}{\sum_{i=1}^n OH_{1,i}} / \frac{\sum_{i=1}^n pp_{1,i} OH_{0,i}}{\sum_{i=1}^n OH_{0,i}}, \quad (3.2)$$

where $pp_{1,i}$ is work productivity in sector i during period 1,

$OH_{0,i}$ is the number of hours worked in sector i during period 0, and

$OH_{1,i}$ is the number of hours worked in sector i during period 1.

The sum of the above increments gives us the total relative difference of work productivity in the entire national economy (for details, see Hindls et al., 2012).

We can see in Tab. 3.1 how the hourly work productivity expressed as a ration of gross added value at constant prices per hour worked has changed.

Tab. 3.1: Changes in work productivity in individual sectors between 2009 and 2016, Czech Republic

G Wholesale and retail; repairs and maintenance of motor vehicles	31%
L Real estate activities	29%
N Administrative and auxiliary activities	26%
C Manufacturing industry	25%
K Banking and insurance	23%
J Information and communication activities	21%
F Construction	14%
I Accommodation, catering and hospitality	12%
A Agriculture, forestry and fisheries	8%
B Mining and quarrying	8%
M Professional, scientific and technical activities	7%
R Cultural, entertainment and recreational activities	6%
P Education	3%
O Public administration and defense; mandatory social insurance	-3%
Q Health care and social security	-3%
T Activities of households as employers and producers for their own purposes	-4%
S Other activities	-9%
H Transportation and storage	-10%
E Water supply; activities related to waste water, waste and remediation	-32%
D Generation and distribution of electricity, gas, heat and conditioned air	-39%

Source: Own figure created using Czech Bureau of Statistics data, GDP, national accounts - National Accounts Database

Hourly work productivity grew the most in trade, maintenance and repairs of motor vehicles (by 31% in the course of the seven years under review), in activities in the real estate sector (29%) and in the sector of administrative and auxiliary activities (26%). The growth in hourly work productivity in the manufacturing industry is of fundamental importance (25%), for two reasons. First of all, it is the most important sector in terms of both the added value created and employment; second, the average number of hours worked per employed person has increased (fig. 3.2), and unlike in the real estate and administrative sectors where the number of hours worked has declined, a part of the growth of hourly productivity cannot be explained for instance by more efficient utilization of working hours.

The most significant decline in hourly work productivity, on the other hand, occurred in utilities, i.e., in generation and distribution of electricity, gas, heat and conditioned air (by 39%), and in the sector of water supply and activities related to waste water, water and remediation (by 32%). A double-digit decline in work productivity further occurred in transportation and storage (by 10%). We can thus see

that developments in hourly work productivity in the relevant period of seven years varied greatly sector to sector.

Tab. 3.2 shows the outcome of the decomposition described by relations (3.1) and (3.2). The total hourly work productivity for the entire national economy rose by 11.9%. The growth of hourly productivity in individual sectors of the national economy accounted for 12.7% of such growth. In other words, if sectoral structure of employment in the national economy did not change, the overall productivity would grow by 12.7%, rather than 11.9 %. Therefore, the change in the structure of the economy had a negative effect on work productivity developments (to the extent of approx. 0.8% over the period of seven years). In other words, in complete conflict with the proposed Industry 4.0 and hitherto statements of various government representatives, employees would shift from higher work productivity sectors to lower work productivity sectors, which situation had a negative impact on year-on-year developments in gross added value, and subsequently also on gross domestic product, to the approximate extent of -0.1 percentage points per year.

Tab. 3.2: Decomposition of the total change of work productivity in the national economy

Δ_{SS}	1,127
Δ_{STR}	0,993
Total change of work productivity	1,119

Source: Own figure created using Czech Bureau of Statistics data, GDP, national accounts - National Accounts Database

4. Age structure of workers in health care and education

The objective of the final chapter is to analyze, in greater detail, the age structure of workers in health care and education, as we have credible data on age structure of the workers available due to the nature of these sectors and the historical tradition of a great quantity of administrative data and quality statistics.

Tab. 4.1 provides the age structure of teachers, broken down by school types and 10-year age intervals.

We can see that there currently nearly 26 thousand teachers in the 56-65 age group, and only a small part of that group will most likely pass to the oldest age group (there are only 1,623 active teachers aged 66 and over). Fewer than 6 thousand graduates per year complete pedagogical courses, and this number has been declining steadily in recent years. In light of the fact that many graduates (according to various sources, approx. 60%¹) never start teaching, and other do start teaching but leave this segment after some time, the number of graduates from colleges of education will not be sufficient to replace the leaving age group. Moreover, many graduates in special education, for instance, head for facilities other than schools, which are not covered in Tab. 4.1.

According to OECD statistics, we already are below OECD member country standard, as regards the Students-to-Teachers ratio, and it will thus probably be impossible to improve this indicator in the near future.

The outlook for the next approx. 15 years is even worse: the strongest age group (46-55) numbering over 47 thousand teachers at present will retire, and to replace them, more than 5 thousand fresh teachers per year would be required (a fresh teacher means a pedagogical course graduate who actually goes to teach).

Tab. 4.1: Age structure of teachers, 2015, Czech Republic

Indicator	Age group					
	Under 25	26–35	36–45	46–55	56–65	66 and over
Kindergartens	2 643	4 752	7 047	11 075	5 269	214
Primary schools	971	10 566	18 767	20 055	10 063	578
Secondary schools, conservatoires and higher vocational schools	190	4 765	9 775	12 644	8 881	745
Schools for pupils with special educational needs	145	1 273	2 626	3 470	1 600	86
TOTAL	3,949	21,356	38,215	47,244	25,813	1,623

Source: Czech Bureau of Statistics – A Close Look at Women and Men - 2016

¹ <http://www.ceskaskola.cz/2017/01/stat-chce-vic-ucitelu-fakultam-prida.html>

A similar analysis can be carried out for health care workers.

Tab. 4.2 captures health care workers as of December 31, 2013, broken down by rank and sex. As of the end of 2013, there were over 266 thousand workers in the health care sector, of that, nearly 209 thousand were women.

Tab. 4.2: Number of health care workers as of December 31, 2013, Czech Republic

Indicator	2013
Health care workers in total	
women	208,843
men	57,429
Of that: professionals in health care	
women	177,791
men	44,448
of that: physicians and dentists	
women	29,230
men	24,680
of that: dentists	
women	5,220
men	2,900
Pharmacists	
women	5,635
men	1,182
Health care workers non-physicians with professional qualifications	
women	108,159
men	5,170
Of that: general nurses and midwives	
women	86,730
men	1,695
Other professional health care workers	
women	34,767
men	13,416
Other health care workers	
women	31,052
men	12,981

Source: Czech Bureau of Statistics – A Close Look at Women and Men - 2014

Let us have a closer look at selected types of workers. As of the end of 2013, there were approx. 47 thousand physicians in the Czech Republic (excl. dentists), see tab. 4.1. The number of graduates from long Master's programs, i.e., the group that fills physician posts, reached 987 in 2015 (this figure refers to graduates who are Czech citizens). Graduates thus account for approximately 2% of the total labor force per annum, which is not sufficient to sustain the labor market in the long run. A more in-depth analysis would have to take migration into account (i.e., both fresh graduates moving abroad and physicians coming to the Czech Republic from abroad). Further, if we look at the age structure of physicians (fig. 4.1), we can see that the largest age group is 55-59 (as of December 31, 2013). A greater drop in labor can thus be expected roughly in 5-10 years, and it is therefore necessary to at least maintain, and preferably increase, the number of new students in medical fields in upcoming years because they will be the ones to reproduce the labor force in 7-10 years.

Dentists are a special group (fig. 4.2). The two largest age groups are obvious (55-59 and 60-64 years of age). Although the total number of dentistry graduates (238 dentistry graduates with Czech citizenship) generally suffices to sustain the labor market of dentists (as of December 31, 2013, there were 8,120, see tab. 4.1), the strong leaving age group of 55-64 will probably be impossible to replace in upcoming years. There is not much time left to resolve this situation given the length of study.

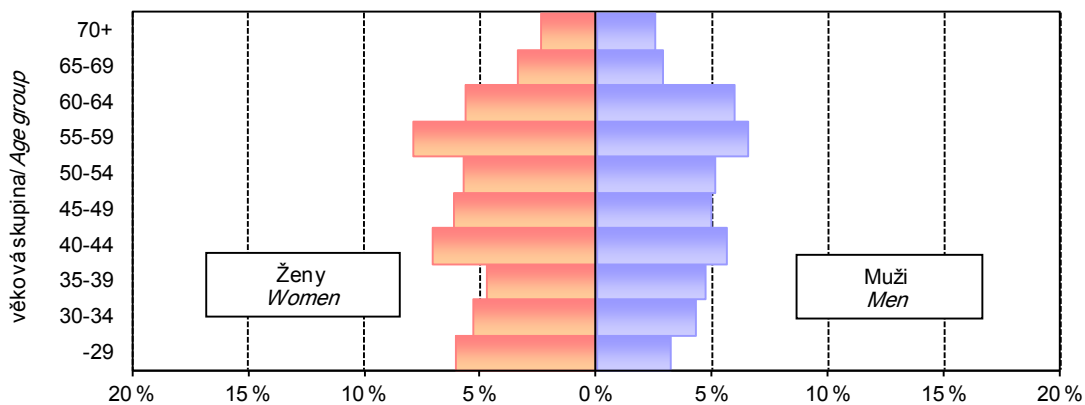
As of the end of 2013, there were fewer than seven thousand of pharmacists in the Czech Republic, the number of graduates with Czech citizenship reached 292 in 2015. The number of graduates appears to be sustainable in light of labor market requirements, the age structure being one of the factors.

The situation appears to be unsustainable as regards general nurses. The analysis of this segment is rather complex because they may be secondary school graduates, graduates of higher vocational schools or Bachelor's programs. However, as we assume that a great majority of university and higher vocational schools previously completed medical courses at secondary schools, the number of general nurses (over 88 thousand, together with midwives, see tab. 4.1) can be compared, at least roughly, to the number of graduates, male and female, of A-level medical courses at secondary schools. In 2016, there were 1,863 of those (fig. 2.26), and this number has been declining steadily since 2014. Moreover, if we consider the fact that this figure does not include general nurses, the future situation concerning general nurses does not appear sustainable, and requires a more in-depth analysis.

The situation is much worse if we look at the official prognosis of the development of population size and structure (tab. 4.3). According to the prognosis, by 2030, the number of inhabitants aged over 65 will grow by 28%, and by a further 28% between 2030 and 2050. That will naturally bring an increased demand for labor, in particular in health care and social services, and the situation appears to be

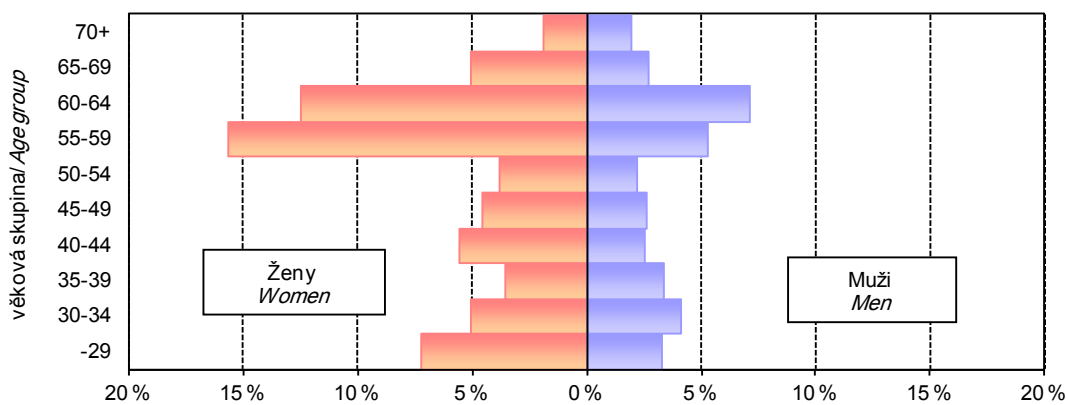
completely unsustainable in particular as regards general nurses and other health care workers at middle level.

Fig. 4.1: Age structure of physicians as of December 31, 2013, Czech Republic



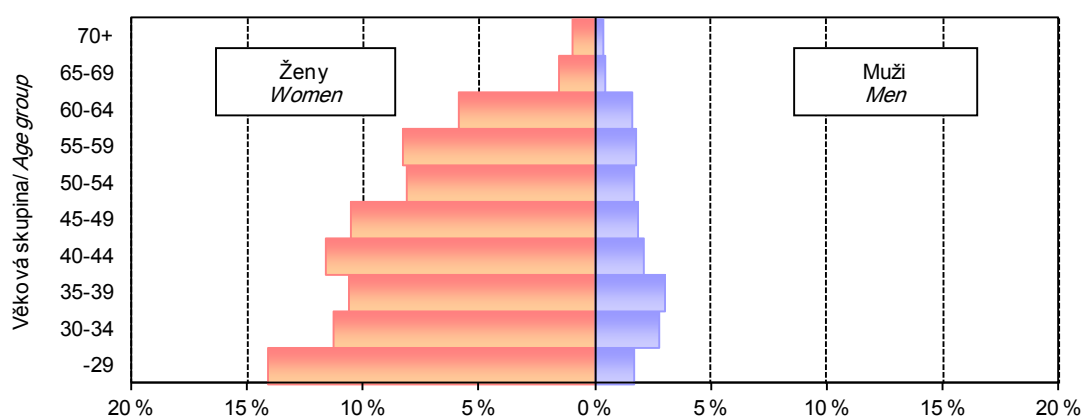
Source: Czech Bureau of Statistics – A Close Look at Women and Men -2014

Fig. 4.2: Age structure of dentists as of December 31, 2013, Czech Republic



Source: Czech Bureau of Statistics – A Close Look at Women and Men - 2014

Fig. 4.3: Age structure of pharmacists as of December 31, 2013, Czech Republic



Source: Czech Bureau of Statistics – A Close Look at Women and Men - 2014

Tab. 4.3: Population structure and projections, as of December 31, 2013, Czech Republic

Age groups (2016)			
Age	total	%	% women
65+	1 939 264	18,4	58,3
15 - 64	6 988 128	66,3	49,3
<15	1 606 203	15,2	48,7
Total	10 533 595	100	50,9

Age groups (2030)			
Age	Total	%	% women
65+	2 483 876	23,9	56,4
15 - 64	6 557 007	63,1	49,2
<15	1 355 818	13	48,5
Total	10 396 701	100	50,9

Age groups (2050)			
Age	total	%	% women
65+	3 158 657	32,2	54,5
15 - 64	5 389 512	54,9	48,9
<15	1 264 703	12,9	48,5
Total	9 812 872	100	50,7

Source: Czech Bureau of Statistics – Population, population prognosis up to 2100 (animated graphs)

Conclusion

The main objective of this study was to analyze developments in the structure of the educational system in 2009-2016, and to compare same to developments in the structure of the Czech economy, with main emphasis on developments in secondary vocational education. The analysis was conducted primarily in the context of national initiative Industry 4.0.

In Chapter 1 which lays down the ground for further analyses, we address a rather significant structural change of the Czech economy in terms of the change of its sectoral structure. While the trend in other transitional economies is such that they are gradually shifting from industries to the service industry, in the Czech Republic, the share of gross added value created in the manufacturing industry in the total gross added value is growing. Such growth amounts to a rather significant 6 percentage points in 2009-2016. The growth in the share of gross added value has as yet not manifested itself significantly in employment structure (the share of persons employed in manufacturing has only increased by two percentage point in the course of the same period), which relates to a marked growth of work productivity in manufacturing. The share of gross added value generated in the sector of manufacture of motor vehicles, trailers and semi-trailers in the total gross added value generated in the manufacturing industry has grown rather substantially, exceeding 20% in 2016; the share of persons employed in the total number of persons employed in manufacturing grew at a slower rate than the share of added value, which can once again be explained by different developments in work productivity in this segment of the automotive industry. At the end of Chapter 1, we present age structure of persons employed in individual sectors, and outline certain problems in the area of education; these are addressed in detail in Chapter 4. On the other hand, the markedly uneven age structure in the mining and quarrying sector, where 58% of the persons employed is over 45, does not necessarily have to pose a problem in light of the gradual phase-out of this sector, as observed in recent years, which phase-out will probably characterize even the near future.

In Chapter 2, the core of this study, we conduct a detailed comparison of developments in the number of persons employed and developments in the number of secondary vocational education graduates in 2009-2016, broken down by graduates with a CVE and graduates with A-levels. In the course of a mere seven years, the system of secondary vocational education experienced significant changes, both in terms of the total number of graduates (in the course of 2009-2016, the total number of graduates dropped by 38.5%), and developments in certain fields of study in particular. The number of graduates has been declining in virtually all sectors within the manufacturing industry. A marked decline in the number of secondary vocational education graduates can be observed in Mining, metallurgy and casting, in textile and clothing production, in manufacture of leather and footwear. In all these three

groups of disciplines, a marked drop in relative figures can be observed; nevertheless, given the small basis for comparison for 2009, the decline is not so great in absolute figures. It is however apparent for instance in the wood processing industry. From the perspective of national initiative Industry 4.0, we consider the substantial decline in the number of secondary vocational education graduates, in particular those with A-levels, in Electrical engineering, telecommunications and computer science, and in Engineering, mechanical engineering, alarming. The number of graduates has been declining in other, non-industrial fields of study as well, e.g., in Agriculture and forestry, Construction or Gastronomy, hotel management and tourism (in the last category mentioned, the decline affected in particular graduates with a CVE). A specific situation prevails in health care, social and educational services, which we deal with in detail in Chapter 4.

At the end of Chapter 2, we address other forms of secondary education by way of an annex, and briefly comment on the situation concerning university graduates. Other forms of secondary education, much as they may be significant for certain disciplines, only accounted for 2% of the total number of secondary vocational education graduates in 2009-2016, and as such certainly cannot save the situation in secondary vocational education. As regards university graduates, we have focused in particular on those fields of university study that are completely indispensable for the pursuit of professions in the relevant sectors. We can see a moderate increase in the number of university graduates in health, medical and pharmaceutical fields, a slight decline in the number of graduates in technical sciences and science, and a marked drop in the number of graduates in teacher training programs. This is subsequently reflected also in the change of structure of university graduates.

In Chapter 3, we observe developments in work productivity in the Czech Republic in 2009-2016 at the level of individual sectors according to CZ-NACE. By way of an introduction, we present various views of statistical depiction of work productivity, and point out the different developments in work productivity when sectoral output is applied to the number of workers on FTE basis on the one hand, and the number of hours worked on the other hand. We can observe a rather marked change in the structure of hours worked in 2009-2016 towards a higher number of hours worked in the manufacturing industry (this is in line with the employment growth expressed as the number of persons employed). We can observe the total increase of gross added value at constant prices in 2009-2016. In light of declarations to the effect that productive activities ought to shift towards sectors with higher added value, or with higher work productivity, we would like to point out that *a contrario*, in 2009-2016, the change in sectoral structure of the economy actually slowed down the overall work productivity growth (by approx. 0.1 p.p. per annum). Developments in work productivity in individual sectors varied greatly in 2009-2016: it grew in the trade sector (31%), in real estate activities (29%), administration (26 %)

or manufacturing industry (25%) on the one hand, and declined (in the course of the same period) in transportation and storage (by 8%), water supply and waste management (by 32%), or in the generation and distribution of electricity, gas, heat and conditioned air (a 39% drop).

Chapter 4 takes a close look at the age structure of workers in health care, social and educational services. The situation in education is dramatic, not only with a view to the age structure of current teachers, with the older age groups prevailing, but also due to the situation in education where the number of graduates of teacher training programs at universities has been declining significantly in recent years, and where moreover many such graduates pursue professions other than teaching after graduation. The situation concerning dentists has not been completely resolved, although there has been some progress in the last ten years. As regards general practitioners, the retirement of the older age group can be managed if the numbers of new students can be sustained in upcoming years. The situation is alarming and completely unsustainable as regards general nurses but appears sustainable as far as pharmacists are concerned.

Last but not least, any labor market prognosis needs to take population size and population age structure projections into consideration, as the aging of the population will inevitably be accompanied by an increased demand for the already endangered health care and social services.

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