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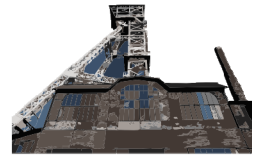
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Functional upgrading through research and development in the Czech automotive industry

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Abstract

Based on firm-level research and development (R&D) data, we evaluate the extent of functional upgrading in the Czech automotive industry between 1998 and 2008. The analysis draws on a unique database of 476 Czech-based automotive firms with 20 and more employees in the broadly defined automotive industry, a survey of 274 automotive firms and twenty-five in-depth company interviews. In addition to assessing changes in the extent of automotive R&D, we analyze the most important locational factors of automotive R&D in Czechia and its regional distribution in the country. We examine changes in the spatial concentration of automotive R&D between 1998 and 2008. The analysis is conducted for foreign-owned and domestic companies separately to evaluate the differences between these two groups of firms. Based on this analysis, we consider changes in the relative position of the Czech automotive industry in European automotive production networks between 1998 and 2008.

Keywords: industrial upgrading, automotive industry, research and development, Czechia

Klíčová slova: průmyslový upgrading, automobilový průmysl, výzkum a vývoj, Česko

Introduction

One of the important features of the internationalization of the automotive industry is the integration of its production networks at the macro-regional rather than global scale. The presence of assemblers in each macro-regional market, such as North America, Western Europe and East Asia, is necessary because of different customer preferences, high transportation costs, just-in-time deliveries and, also, various tariff and non-tariff barriers (Sturgeon et al. 2008). The logic of modular production also dictates the geographic proximity of assemblers and first-tier suppliers (FTSs) (Pavlínek and Janák 2007). Thus, the automotive industry's spatial division of labor is primarily developed at the macro-regional rather than global scale.

Based on the position of countries in the automotive value chain, Domanski and Lung (2009) describe the simplistic core-periphery spatial pattern of the organization of the European automotive industry. The core „blue banana“ regions in Germany, France, Italy and, to some extent, the UK host the headquarters (HQs) of assemblers and global suppliers. Crucial technological capabilities and strategic functions generating high value added, such as design, R&D and marketing, also remain concentrated in these regions. Lower tiers of the automotive value chain, such as the labor-intensive assembly and production of small cars and simple components, tend to be concentrated in the European

periphery, which includes Czechia and other CE countries. Semi-peripheral countries and regions, such as Austria, Belgium, Eastern Germany and Spain, developed higher value-added production and R&D but they lack core functions associated with corporate HQs.

However, at the same time, Domanski and Lung (2009) emphasize the dynamic and relational character of the European periphery, parts of which, such as the CE countries, have increasingly specialized in the manufacturing of more complex and more sophisticated higher value-added products. They also argue that the peripheral position of countries is not necessarily permanent. For example, Spain shifted from the peripheral position in the 1970s and 1980s to the semi-peripheral position in the 1990s, while the UK automotive industry retreated from the core position. Pavlínek et al. (2009) showed that the share of higher value-added automotive products increased in CE between 1996 and 2006. They also emphasized the geographically highly uneven nature of automotive R&D in CE.

This paper focuses on Czechia, the largest passenger car producer in CE. Czechia combines the advantages of geographic location with its industrial tradition and technically skilled labor force. Based on the highest R&D expenditures in CE (Pavlínek and Ženka 2010), Czechia seems to be improving its position in the European automotive value chains faster than other CE



countries. The first research question of this paper is thus whether and to what extent the Czech automotive industry has been moving from its peripheral towards a more semi-peripheral position in the European automotive value chains. The second research question is whether and to what extent the functional upgrading through R&D has been taking place in the Czech automotive industry during the period of large FDI inflows into the Czech economy between 1998 and 2007.

2. Industrial upgrading

Industrial upgrading is a process by which firms, regions and countries improve their position in various value chains. Humphrey and Schmitz (2002) distinguish between process (introduction of more efficient production methods and better technology), product (shift to the production of higher value-added products), functional (acquiring strategic functions generating higher income) and inter-sectoral upgrading (expansion to new and more profitable sectors). Empirical results of Pavlínek and Ženka (2010) and 25 interviews conducted between December 2009 and May 2010 revealed a significant FDI-driven product and process upgrading in the Czech automotive industry between 1998 and 2006. Czech-based automotive firms are comparable in terms of productivity, technological equipment and organization to their western counterparts. However, the increasing specialization of the CE automotive industry in the production and export of higher-value-added components tells us nothing about the skill content and technology intensity of production.¹ Neither it tells us how much value is generated and added in a particular region.

Perhaps the greatest difference between the Czech automotive industry and the core EU countries is the virtual nonexistence of strategic knowledge-intensive nonproduction and production functions generating high value-added in Czechia, such design, R&D, logistics, marketing and accounting. Functional upgrading is thus the most important mechanism through which the Czech automotive industry can narrow this gap and move to a semi-peripheral position. In this paper, we analyze functional upgrading only through R&D functions because it is the only available indicator allowing for international comparison in time series.

3. Data

The analysis of the Czech automotive R&D draws on a unique database of 476 Czech-based automotive firms

¹ The best example is Hungary with 58.4% share of high-value-added components in total exports in 2006, resulting from the specialisation in the assembly of engines.

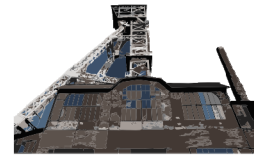
with 20 or more employees in the broadly defined automotive industry. Employment and financial indicators for the 1998-2007 period were obtained from the “Annual Survey of Economic Subjects in Selected Industries“, R&D data are based on the “Annual Statistical Survey of Research and Development” (VTR 5-01). The international comparison of the EU countries in terms of automotive R&D is based on the Eurostat Structural Business Statistics database. To ensure international comparability, we only use data for the narrowly defined automotive industry (NACE 34ⁱⁱ). For the purposes of more detailed analysis of the Czech automotive R&D, we also analyze the broadly defined automotive industry, including firms from supplying industries, such as machinery, electronics, plastics and other industries (weighted by the share of automotive industry in their turnover).

4. R&D in the EU automotive industry

The privatization and consolidation of the CE automotive industry in the first half of the 1990s was followed by a significant growth in the automotive production and employment since the mid-1990s (e.g. Pavlínek et al. 2009). Although this production increase has not significantly altered the spatial organization of the European automotive industry and the majority of production facilities and jobs remained concentrated in the core EU countries, Czechia and Poland produced more passenger cars than Italy and Russia in 2009 and became the 5th and the 6th largest car producers in Europe (OICA 2010). The total Czech and Polish automotive employment was only 15-20% smaller than in significantly larger EU countries, such as Spain, Italy and the UK (Eurostat 2010).

While the production increased in CE, the vast majority of automotive R&D remained concentrated in the EU core, whose position became even more dominant in the case of Germany and France. Between 1999 and 2007, R&D expenditures in the German automotive industry grew by 104%. By 2007, the share of Germany in the total EU automotive R&D expenditures reached almost 70% (Eurostat 2010). Although in the past decade the fastest relative growth in automotive R&D expenditures took place in CEE, it was from an extremely low base in countries, such as Slovakia, Romania and Hungary. Consequently, its overall effect was negligible in the European context. Outside the European core, the most notable trend was the rapid growth in R&D expenditures in Czechia and Austria, the two countries located close to the German core. R&D expenditures in the Czech automotive industry quadrupled between 1997 and 2008 and they exceeded the total combined automotive R&D

ⁱⁱ We use the industrial classification NACE rev. 1.1 in order to ensure compatibility of data in time series.



expenditures of Hungary, Poland, Slovakia and Slovenia. In 2006, the Czech automotive R&D expenditures surpassed those of Spain, despite the fact that Spain produced twice as many cars annually.

Technological intensity of production measured by R&D expenditures in value added revealed two contradictory trends in the CE countries. On one hand, the total R&D

expenditures increased significantly and faster than in Western Europe (Table 1). On the other hand, except for Hungary and Slovenia, the share of R&D expenditures in value added was falling because of rapid increases in production and employment fuelled by large FDI inflows. Consequently, value added was growing faster than R&D expenditures (Pavlínek and Ženka 2010).

Table 1 Trends in NACE 34 R&D expenditures/employment in selected EU states 1997-2007

| | R&D expenditure (mil. EUR) | | | R&D expenditure in value added (%) | | | R&D personnel total | | | R&D personnel in employment (%) | | |
|----------|----------------------------|--------|--------|------------------------------------|------|------|---------------------|--------|--------|---------------------------------|------|------|
| | 1997 | 2002 | 2007 | 1997 | 2002 | 2007 | 1997 | 2002 | 2007 | 1997 | 2002 | 2007 |
| Austria | 124 | 311 | 324 | 7,8 | 13,9 | 10,0 | 1 068 | 1 775 | 2 072 | 4,1 | 6,3 | 6,1 |
| Belgium | 67 | 77 | 124 | 2,3 | | 4,0 | | | | | | |
| Czechia | 81 | 175 | 290 | 8,8 | 8,9 | 6,7 | 2 075 | 2 536 | 3 252 | 3,3 | 2,8 | 2,7 |
| Germany | | 13 621 | 17 587 | | 24,8 | 24,0 | | 78 111 | 83 155 | | 8,9 | 9,8 |
| France | 1 906 | 2 677 | 3 490 | 13,4 | 14,5 | 20,0 | 18 883 | 26 671 | 30 912 | 6,8 | 9,4 | 5,3 |
| Hungary | 4 | 11 | 50 | | 0,9 | 1,8 | | 990 | 876 | | 2,7 | 1,6 |
| Italy | | 688 | 1 000 | 8,1 | 11,1 | 9,6 | 9667 | | 8 833 | 5,1 | | 5,2 |
| Poland | 26 | 10 | 27 | 2,4 | 0,7 | 0,7 | | | 1 118 | | | 0,8 |
| Romania | | | 35 | | 1,7 | 0,1 | | 1 468 | 1 070 | | 2,1 | 1,7 |
| Slovakia | 2 | | 3 | 2,0 | | 0,2 | 153 | 112 | 72 | | 0,6 | 0,2 |
| Spain | | 294 | 254 | | 3,7 | 2,6 | | | 3 664 | | | 2,4 |
| Sweden | 1 201 | 1 278 | 1 537 | | 31,0 | 24,8 | | 9 570 | 9 567 | | 13,0 | 11,2 |
| UK | | 1 360 | 1 364 | 9,4 | 10,8 | 9,3 | | | 9 454 | | | 5,7 |

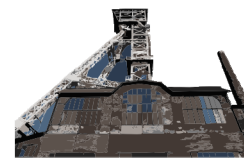
Source: Eurostat 2010, national statistical office of selected EU states

5. R&D in the Czech automotive industry

While the analysis in the previous section was based on the comparison of the narrowly defined automotive industry (NACE 34) of particular EU countries to ensure data compatibility, the analysis of the Czech automotive R&D uses data for the broadly defined automotive industry, which had 172,331 employees in 2007. As such, it was by far the most important industry in Czechia in 2007 with a 14.8% share of total employment, 22.7% of R&D employment and 41.2% of R&D expenditures of the Czech manufacturing industry as a whole (MIT 2008) This high level of concentration of R&D in the automotive industry explains a strong position of the Czech automotive R&D compared to other CE countries and Spain. The share of the (narrowly defined) automotive industry in total manufacturing R&D expenditures reached 39,1% in Czechia, 3.5% in Slovakia, 11.7% in Poland, 16.3% in Hungary and 7.4% in Spain in 2007 (Eurostat 2010).

The Czech automotive R&D is typified by a high level of concentration into a single firm, Škoda Auto, which accounts for more than 75% of the total. Thus, the presence of a tier two focal firm (Pavlínek and Janák 2007) explains much higher automotive R&D expenditures in Czechia compared to other CE countries. Without Škoda Auto, the Czech automotive R&D expenditures would be only slightly higher than those of Hungary and thus would be comparable to other CE countries. Five Czech-based firms with the largest R&D expenditures, which include Škoda Auto and four FTSS, accounted for 80.8% of the overall increase in R&D expenditures between 1995 and 2007. Thus, the total automotive R&D expenditures in Czechia were not significantly influenced by the establishment of many small R&D centers during this period.

There are two basic reasons for a strong R&D at Škoda Auto. First, according to the 1991 agreement between Volkswagen and the Czech government, Škoda Auto retained its brand and it was integrated into the corporate structure of VW as a manufacturer of small and cheap



passenger cars (see Pavlínek 2008 for details). As a result, the existing pre-1989 R&D was first maintained at Škoda Auto in the early 1990s and, later, R&D functions were further developed to support the increasing production and variety of Škoda models. The basic goal of Škoda's R&D is to adapt VW technologies for Škoda models and to design Škoda models based on the VW Group's platforms. Second, before its 1991 acquisition Škoda Auto had relatively large R&D facilities and the Mladá Boleslav region had one of the largest pools of highly skilled workers in Central and Eastern Europe. To capitalize on cheaper and skilled R&D labor force, VW transferred some routine R&D operations such as computer aided design to Škoda Auto in the 1990s (Pavlínek 2004).

Škoda Auto thus illustrates the path-dependent localization nature of FDI into technology and R&D centers in CE. In 1989, the former Czechoslovakia and East Germany were the only CEE countries that were designing and developing their own passenger cars, while the remaining CEE countries were producing cars based on licensed western technologies (Pavlínek, 2002). Ženka and Čadil (2009) argue that the existing regional distribution of manufacturing R&D in Czechia has been strongly influenced by the pre-1989 distribution of R&D centers in the automotive, machinery and electronic industry. After 1989, the majority of factory-related R&D centers in the Czech automotive industry survived after being acquired by large foreign TNCs in the form of acquisitions or joint ventures with domestic companies. Foreign owners often retained these R&D facilities to capitalize on the existing know-how and skilled R&D labor force. More recently, the well-developed supplier sector, industrial tradition, level of technical education, government investment incentives and the need of FTSS to closely cooperate on R&D with assemblers favored the further development of technological centers by foreign TNCs in Czechia.

6. The 1995-2009 trends in the Czech automotive R&D

Based on our empirical analysis and the conclusions of Pavlínek and Ženka (2010), we have identified basic trends in the development of the Czech automotive R&D in the broadly defined automotive industry since the mid-1990s. These include its extremely uneven nature reflected in the highly selective functional upgrading, the

rapid expansion of R&D facilities by foreign TNCs, the changes in the size/branch structure of R&D, and the increasing technological complexity and knowledge content of R&D activities.

The expansion of the automotive R&D facilities is reflected in the growing number of firms conducting R&D and in the increasing R&D expenditures and growing R&D employment (Table 2). While the number of larger automotive R&D centers with 100 and more employees increased only by one from 4 in 1995 to 5 in 2007, the number of small R&D facilities with less than 20 employees grew from 35 to 88 in the same period. Pavlínek et al. (2009) also highlighted the existence of newly established stand-alone automotive R&D centers, usually located in metropolitan areas in order to access skilled labor force. Between 1995 and 2007, R&D expenditures increased by 79% and the annual growth fluctuated significantly, reflecting R&D investment by the largest FTSS and assemblers. The R&D employment grew steadily during this period with the fastest increase taking place between 2005 and 2007 when several FTSS expanded their technological centers.

Significant changes took also place in the branch structure of the broadly defined automotive industry R&D. The most notable trend was the steadily growing share of the manufacturing of automotive components (NACE 34.3) in total R&D employment from 12.0% in 1995 to 33.6% in 2007. The share of the supplier sector on total automotive R&D employment reached 53.7%, surpassing the traditionally stronger assemblers. Similarly, the share of automotive suppliers on total R&D expenditures increased from 8.6 to 28.6%. In the middle of the 1990s, the Czech automotive R&D was dominated by Škoda Auto and, to a lesser extent, by truck and bus manufacturers, major component suppliers classified in NACE 34.3, and by large firms in capital-intensive industries, such as metallurgy, basic chemicals/plastics and tires. These companies were established before 1990 and some of them were acquired by foreign TNCs after 1990. By 2008, the situation had changed. Škoda Auto retained its dominant position. The position of truck and bus manufacturers weakened, although those who survived stayed among the TOP 20 firms. Large foreign-owned FTSS significantly improved their position. The Czech automotive R&D became almost completely controlled by foreign TNCs.

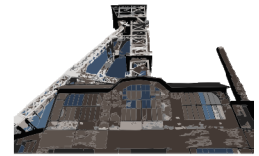
Table 2 Functional upgrading in the broadly defined Czech automotive industry

| | 1995 | 1998 | 2002 | 2006 | 2007 | 2007/1998 |
|-----------------------|------|-------|--------|--------|--------|-----------|
| Employment | | 91391 | 128902 | 168867 | 172331 | 189 |
| Value added | | 46999 | 79066 | 136499 | 150009 | 319 |
| Number of R&D centers | 49 | 53 | 64 | 120 | 119 | 225 |
| R&D personnel | 2428 | 2467 | 2585 | 3646 | 3972 | 161 |



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| | | | | | | |
|--|------|------|------|------|------|-----|
| R&D personnel MD_PhD | 747 | 734 | 981 | 1860 | 1998 | 272 |
| R&D expenditure | 2291 | 4735 | 6048 | 8573 | 8455 | 179 |
| R&D personnel in employment (%) | | 2,7 | 2,0 | 2,2 | 2,3 | 85 |
| R&D expenditure in value added (%) | | 10,1 | 7,6 | 6,3 | 5,6 | 56 |
| R&D expenditure per employee (thous. CZK) | | 51,8 | 46,9 | 50,8 | 49,1 | 95 |
| Share of R&D personnel with Master and Ph.D. degrees (%) | 30,7 | 29,8 | 38,0 | 51,0 | 50,3 | 169 |

Note: Financial indicator in mil. CZK if not stated otherwise.

Source: Czech Statistical Office 2010

The rising share of university graduates and researchers in total R&D staff between 1995 and 2007 illustrates the increasing knowledge content and the changing nature of R&D. It increased by 810% in supplier firms classified in NACE 34.3 and by 150% in assembly firms (NACE 34.1). Two major FTSs with largest R&D centers accounted for 52.9% of the total increase. During the same period, assemblers experienced an increase from 51.9% to 75.4% in the share of researchers in their total R&D employment (from 979 to 1,472 researchers). The change in the supplier sector was less clear and it fluctuated significantly. Its share of workers with graduate degrees among R&D personnel was higher than among the assemblers. However, the share of researchers among R&D personnel was lower. It suggests the prevalence of technicians among R&D personnel and the concentration of suppliers' R&D on technical support, adaptation, testing and development of vehicle parts/components rather than on applied and basic research. This could be further illustrated by a simple comparison of the structure of R&D expenditures according to the type of R&D. In 2007, Czechia reported a 97.1% share of experimental development in its total R&D expenditures. The share of basic and applied research was very low, only 0.5% and 2.3%, respectively. Although the share of basic research is also very low in the West European countries, such as Spain (0.5%), the UK (1.4%), Austria (3.3%) and France (4.0%), they have a much higher share of applied research than Czechia (France 31.0%, Spain 30.1%, Austria 20.5 and UK 16.2%). This concentration of the Czech automotive R&D on the lowest development activities underscores the limits of industrial upgrading of the past two decades and points towards the persistence of peripheral position of the majority of the Czech-based firms in the European automotive production networks. Basic research in the Czech automotive industry was conducted mainly by a small group of suppliers outside NACE 34 not directly connected to the automotive industry such as in metallurgy, basic chemicals, and aerospace industry. Surprisingly, the share of R&D workers in total employment was not higher in WE countries compared to Czechia (51.8% in 2008) or Hungary (76.4%). On the contrary, France reached in 2007 only 46.5%, Austria 43.8%, UK in 2008 56.6% and Spain even only 24.8%.

7. Conclusion

A significant functional upgrading was taking place in the Czech automotive industry despite its predominantly extensive growth during the period of large FDI inflows between 1998 and 2007. The number of R&D centers increased by 67, both R&D employment and expenditure grew twice as fast as in the core EU countries. At the same time, functional upgrading was highly selective (see Pavlínek and Ženka 2010). A significant R&D expansion was largely limited to Škoda Auto and to a small group of foreign FTSs. A relatively strong automotive R&D in Czechia compared to other CE countries can be explained by the presence of Škoda Auto, a tier two focal firm, in Czechia and by the path dependent nature of the Czech automotive R&D. The majority of large factory-related R&D centers had been established before 1990. After 1990 they were acquired and further expanded by TNCs.

Our analysis suggests that the Czech automotive industry has been shifting its position towards the European automotive industry semiperiphery in the European automotive division of labor. Its position in the European automotive industry system is increasingly comparable with countries such as Austria, Belgium and Spain. However, the overrepresentation of experimental development in the Czech automotive R&D, its orientation on less sophisticated functions, such as technical support of production and the product adaptations or development for the local or CE market (see also Žížalová and Csank 2009), point towards the persistence of strong peripheral tendencies in the Czech automotive industry despite the relatively high knowledge content of the Czech automotive R&D. A further detailed qualitative analysis of R&D activities is thus needed to clarify the nature of the Czech automotive R&D and its position in the European division of labor.

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XXII SJEZD ČESKÉ GEOGRAFICKÉ SPOLEČNOSTI OSTRAVA 2010



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