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# Automation, skill requirements and labour-use strategies: high-wage and low-wage approaches to high-tech manufacturing in the automotive industry

Martin Krzywdzinski

***In light of debates about advanced manufacturing and concepts like Industrie 4.0, this article compares labour-use strategies in highly automated automotive supplier plants in a high-wage country (Germany) and a low-wage region (Central Eastern Europe). It shows considerable differences regarding skill requirements on the shop floor and the use of precarious employment contracts and examines three potential factors that explain them: national institutional frameworks, the power of employee representatives and the role of the plant within the companies and value chains. The analysis shows that the labour-use strategies depend less on process technologies per se, but rather on the institutional framework and the role of the factory in the rollout and ramp-up of new products and new process technologies. Such a role requires close cooperation between employees in the manufacturing areas and in product development, which in turn requires particularly high skills. The role of employee representatives in influencing labour-use strategies proves less important. The article uses quantitative data from a survey of employee representatives, as well as qualitative data from in-depth company case studies.***

**Keywords: automation, skills, automotive industry, trade union, *Industrie 4.0*, temporary employment, technology, international division of labour.**

## Introduction

The relationship between the use of technology in the workplace and employee skills has been the subject of many classic debates (Braverman, 1974; Piore and Sabel, 1984; Adler, 1988). Today, this relationship is being discussed anew, albeit with a focus on advanced manufacturing technologies. With initiatives like *Industrie 4.0*, *Industrie du Futur*, *Advanced Manufacturing Initiative*, *Made in China 2025* and many more, most industrialised and industrialising countries have set up national programmes aimed at supporting companies in the intensifying competition over global leadership in manufacturing (President's Council of Advisors on Science and Technology, 2011;

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Forschungsunion and Acatech, 2013; Butollo and Lüthje, 2017). The main issues are not only new data-driven business models but also new production concepts based on the Internet of things (industrial Internet) and new robotics concepts.

The implementation of new production concepts promises to bring radical change to labour processes, but forecasts differ in their predictions of the nature of these changes. Some authors argue that the regulation of new production systems will require highly skilled workers, while low-skilled jobs will gradually disappear due to automation (Autor *et al.*, 1998; Brynjolfsson and McAfee, 2014). This could help traditional industrialised countries to regain manufacturing employment because they have a highly skilled workforce experienced in working with highly automated processes. Other authors warn that new technologies could reinforce the polarisation of employment structures, that is, they could eliminate routinised medium-skilled routine jobs, resulting in a dichotomy between high-skill jobs and low-skilled manual workers performing residual tasks that cannot be automated (Frey and Osborne, 2013; Carr, 2014; Eurofound, 2014; OECD, 2017).

As new production concepts have been introduced in an often-experimental fashion in the context of *Industrie 4.0* and similar approaches, empirical analyses of their consequences are still lacking. While the relationship between skills and technological change has been hotly debated in economics for more than a decade (Oesch and Rodriguez Menes, 2011; Autor and Dorn, 2013; Goos *et al.*, 2014; to name some recent publications), industrial and labour sociology is only beginning to reflect on the new developments (Howcroft and Taylor, 2014; Edwards and Ramirez, 2016; Hirsch-Kreinsen, 2016; Briken et al., 2017; Gallie, 2017).

An important characteristic of existing studies is that they concentrate on a relatively small number of affluent countries (the USA and Western European countries). There are hardly any recent studies examining the relationship between technology and skills in countries with a different position in the international division of labour (the only exception, to the author’s knowledge, is Maloney and Molina, 2016). Due to the different factor endowment and institutional settings, however, considerable differences between high-wage and low-wage countries can be expected. Against this backdrop, this article presents an empirical analysis of the relationship between automation and labour-use strategies (analysed here with a focus on skills on the shop floor and the use of short-term, precarious employment contracts). Based on a research project conducted in 2015 and 2016, the article compares highly automated automotive supplier plants in a high-wage country (Germany) and a low-wage region (Central Eastern Europe, CEE).

The study has two broad aims. First, it seeks to establish the extent to which, and the ways in which, labour-use strategies might differ between high-wage and low-wage countries. Second, when differences can be identified, it examines what factors might explain such differences.

The analysis combines quantitative and qualitative methods and is based on a survey of employee representatives in automotive supplier plants, as well as on eight in-depth case studies in automotive supplier companies. Its starting point are three hypotheses regarding the main determinants of the differences between high-wage and low-wage locations: The first emphasises the national institutional settings, and in particular vocational education systems; the second focuses on influence of employee representatives on job design and skill use (politics in the workplace); the third looks at the role of the plants in implementing new products and process technologies, as well as the related prerequisites for cooperating with product development, equipment manufacturers and other functions.

The article is structured as follows. Section 2 reviews the research literature and develops the hypotheses for the analysis. Section 3 presents the data and methods used in the article. Section 4 compares the skill requirements and labour-use strategies employed in German and CEE plants by automotive suppliers, while Section 5 develops the explanation for these differences. Section 6 discusses the overall conclusions.

## Literature review and hypotheses

### The recent debates about automation

Automation is a well-known phenomenon in the manufacturing and service sectors, and it is a core topic of labour sociology, because revolutionising the productive forces is a constant imperative of capital. This process has occurred, however, in waves, which have given rise to recurring research debates. The relationship between automation and skills was a core issue during the introduction of the first robots and numerically controlled machine tools (Noble, 1986) and during the introduction of computer-integrated manufacturing concepts in the 1980s and 1990s (Adler, 1992); it has likewise been an issue in recent discussions.

Today's debate about the digitalisation of work in manufacturing and services refers to a number of technological developments, some of which represent forms of automation and some of which do not. A core topic related to automation is the development of so-called 'cyber-physical systems', that is, self-regulating constellations of objects (not only machines but also parts) that communicate through the Internet of things (Höller *et al.*, 2014) and utilise new sensor technologies and real-time computing techniques. A second important development in the field of automation is the emergence of new, flexible lightweight robots which 'leave their cages' and are capable of working side by side with humans. Other important trends that do not represent automation are the use of digital assistance systems (not only tablets but also data glasses, smart watches etc.) in work processes. Some authors also mention the introduction of artificial intelligence solutions in companies as a way of automating some areas of white collar work (Brynjolfsson and McAfee, 2017)—but such developments are still more fiction than reality.

The described developments represent the background for a new global race for leadership in the new digitalisation and automation technologies. Several countries have established national initiatives and campaigns to promote their industries and economies. The most well-known is the *Industrie 4.0* campaign from Germany (Forschungsunion and Acatech, 2013; Pfeiffer, 2016). This initiative was started by the state, business associations and trade unions, and aims to promote the development of new technologies, the creation of model factories and reference solutions, and the definition of standards. Due to the high levels of public and private investment and the large number of participants, it has managed to make a considerable impact. France has followed the German example with a similar programme under the name of *Industrie du Futur*. The Obama administration in the United States initiated the Advanced Manufacturing Initiative to improve cooperation between basic research and companies (President's Council of Advisors on Science and Technology, 2011); at the same time, a number of huge companies have created the Industrial Internet Consortium to develop exemplary solutions and standards for the new technologies. China has started a huge programme called *Made in China 2025*, which includes a high number of sub-initiatives ranging from efforts to develop cutting-edge technology in robotics and industrial Internet to programmes aiming at modernising traditional labour-intensive industries by introducing conventional automation concepts (Butollo and Lüthje, 2017). All these global initiatives and campaigns differ in size and the specific design, but all have a focus on digitalisation and automation in common.

### The relationship between automation and skills

The relationship between automation and skill requirements is controversial. The current debate is strongly dominated by contributions from economics. Computerisation, digitalisation and automation became important issues in the American debate from the mid-1990s onwards and were thought to be responsible for changes in the US employment structure. The dominant approach in economics is the theory of skill-biased technological change, which argues that technological progress increases demand for high skills and reduces demand for low-and medium-level skills (Autor *et al.*, 1998; Antonietti, 2007; Brynjolfsson and McAfee, 2014; Katz and Margo, 2014). Recent contributions (Acemoglu and Autor, 2010) recognise also limits to automation in the low-skill area, but these limits are not rooted in the specific knowledge held by workers, but rather in requirements for manual dexterity and in limits to the routinisation of the tasks. The resulting scenario is a polarisation of the employment structure with a decreasing share of medium-skilled jobs (Eurofound, 2014; OECD, 2017).

The debate in economics relies mainly on occupational statistics and measures shifts between occupations and on the sectoral level. Transformation processes within firms remain a black box and the new forms of automation are captured through relatively rough and contestable indicators like, for instance, company expenses for ICT services, which are interpreted as an indicator of the substitution of human jobs by computers (Autor and Dorn, 2013; OECD, 2017).

The opening of this black box has traditionally been the domain of labour sociology. Yet, labour sociologists have also disputed the relationship between automation and skills. While some authors postulated a positive relationship between progress in production technologies and skill levels (Piore and Sabel, 1984; Adler, 1988), others perceived automation as a driver of the continuing Taylorist organisation of work and management control, leading to a deskilling of work (Braverman, 1974). However, many empirical analyses conducted in the 1980s and 1990s did not confirm a uniform deskilling trend, but instead showed a polarisation of skill requirements and structures in companies (Gallie, 1991; Milkman and Pullman, 1991; Jürgens *et al.*, 1993; Schumann *et al.*, 1994).

An important result of the sociological debates about automation and skill change in the 1980s and 1990s was the finding that there is no universal relationship between the two (Hall, 2010; Briken *et al.*, 2017). In particular, theorists from the labour process analysis tradition pointed out that the workplace is a ‘contested terrain’ (Thompson and Harley, 2007: 149) and noted that the impact of automation on skills and employment structures depends to a large extent on workplace politics (Smith and Thompson, 1998). Research conducted in the labour process theory tradition emphasises the role of worker resistance in the implementation of new production technologies (Hall, 2010; Edwards and Ramirez, 2016). Workers’ tacit knowledge and their potential to disturb the labour process are considered to be key factors that can block the introduction of new technologies or compel management to take workers’ interests into account. Studies of the automotive industry show that the managerial choice of production technologies is not simply a result of cost considerations, but rather the outcome of a complex decision-making process in which employee representatives and collective bargaining play an important role (Jürgens *et al.*, 1993; Wallace, 2008). Institutional factors proved also to be important. Scholars focusing on the Continental European (and in particular German) experience highlighted the role and influence of employee representatives (works councils), because notably the German Works Constitution Act offers a number of options to influence the implementation and use of technology in the workplace (Jürgens *et al.*, 1993; Mumford, 2006).

Building on these experiences, recent sociological publications engaging with the new automation concepts emphasise that their development path is much less certain than the debate in economics suggests and that their impact on jobs and skills will depend ‘on specific application conditions, system functions and structural workplace conditions’ (Hirsch-Kreinsen, 2016: 7; see also Wickham, 2011; Pfeiffer, 2016; Gallie, 2017).

**Institutions, actors and the international division of labour**

In the recent sociological debate, there has been a lack of studies comparing the relationship between automation strategies and skills across countries or across different locations of multinational companies. This is surprising because international comparisons offer a particular opportunity to study how companies cope with automation under different conditions, including institutions, education systems and actor constellations.

Looking at conventional knowledge, differences between high-wage and low-wage countries can be expected regarding the relationship between automation and skills.

The following analysis focuses on the example of Germany as a high-wage country and CEE (Poland, Czechia, Slovakia and Hungary) as a European low-wage region. Differences between the two may result from different factor costs. Hourly labour costs in manufacturing sectors in CEE are only 20 per cent (Poland) to 26 per cent (Slovakia) of the German level. This could be assumed to result in a lower automation level in CEE plants, but this is not exactly the case. Research has shown that automation is often driven by requirements regarding product quality and the stability of the production process as well as by a company's internal standardisation of its production systems (Schoenberger, 1989; Krzywdzinski, 2016). For this reason, there are a number of highly automated factories in low-wage countries. But does this also imply similar labour-use strategies to those present in high-wage locations?

Even focusing on highly automated manufacturing only, different labour-use strategies could be found in the case of Germany and CEE for a number of reasons. The first one is the different institutional systems, in particular, in the field of vocational education. Building on the varieties of capitalism literature (Hall and Soskice, 2001), Busemeyer and Vossiek (2016) suggest a typology of skill formation systems based on two core dimensions: the public commitment to vocational training and the involvement of firms in initial vocational training. They rank Germany high on both dimensions and classify it as a 'collective skill formation system'. As extant research shows, the strength of the German system is based, first of all, on the combination of theoretical education in vocational schools and highly structured practical education in the workplace. Second of all, the system is characterised by a continuing modernisation and adaptation to economic and technological changes (Bosch, 2010). Vocational education also plays an important role in CEE, as the data from the European Center for the Development of Vocational Training show (CEDEFOP, 2015). Around 70 per cent of secondary-level students in the Czech Republic and Slovakia are enrolled in vocational education programmes; in Poland, the share is around 50 per cent (similar to Germany), and it is around 30 per cent in Hungary. There are, however, considerable differences between CEE and Germany regarding the role of workplace practical training. Eighty per cent of all VET students in Germany are enrolled in dual programmes including workplace training. In Hungary, the corresponding share is 70 per cent; in the Czech Republic and Slovakia it is around 40 per cent, and in Poland it is only roughly 15 per cent. In addition, workplace training in CEE countries is considerably shorter and less structured than in Germany, and often only involves an internship. Vocational schools additionally suffer due to their outdated curricula and equipment (Bluhm, 2001; Jürgens and Krzywdzinski, 2010; CEDEFOP, 2015). Given these institutional differences, it can be expected that skill formation regimes in CEE do not to provide the same level of technological and practical knowledge and experience as the German approach does. This could result in a lack of highly skilled blue collar workers on the labour market and push companies towards strategies focusing on employing low-skill workers on the shop floor.

These arguments lead to the first hypothesis:

H1: Given the same level of automation, different institutional skill formation regimes in Germany and CEE can be expected to lead to different labor use strategies in companies.

Institutional embeddedness is, however, not the only possible explanation for differences in labour-use strategies. An alternative explanation is the role and power of actors, in particular, in the field of industrial relations. The strong position of IG Metall, the influence of trade unions based on co-determination systems, and the tradition of cooperative industrial relations in the German automotive industry have been described in many studies, even though recent contributions identify signs of erosion in this constellation (Greer, 2008; Haipeter et al., 2012; Lippert et al., 2014). In contrast, CEE is characterised by considerably weaker trade unions with fewer rights, which have to engage with more hostile employers (Krzywdzinski, 2010; Meardi *et al.*, 2013; Drahokoupil *et al.*, 2015).

This leads to the second hypothesis:

H2: The power held by employee representative bodies (works councils, trade unions) in the workplace influences the relationship between automation and skill requirements. Given the same level of automation, strong employee representation can enforce a job design that puts the emphasis on job enrichment and vocational skills.

Differences between high-wage and low-wage locations regarding the relationship between automation and skills may also relate to the different roles of those locations within the multinational companies and global production networks. Germany is a core country in the automotive sector, and it is the seat of many corporate headquarters and R&D centres. CEE emerged in the beginning of the 1990s as an important location for automotive manufacturers and suppliers; Poland, Slovakia, Czechia and Hungary developed into a highly integrated automotive cluster. During the 1990s, the factories in this region mostly remained limited to simple, labour-intensive assembly processes with low value added, but in the second half of the 1990s, an impressive upgrading process started (Pavlinek *et al.*, 2009; Jürgens and Krzywdzinski, 2010). As Jürgens and Krzywdzinski (2009) showed, this upgrading included a technological modernisation of the sites, the adaptation of company-wide standard production systems, the broadening of CEE site competences (regarding engineering, logistics, purchasing etc.), and a modernisation of the product range. While CEE countries differ in many respects, they are quite similar regarding both these upgrading processes and the overall status of the CEE economies as 'dependent market economies' (Nölke and Vliegenthart, 2009) dominated by multinational companies. With only a few exceptions, research and development (R&D) in the European automotive industry is still very much concentrated in the main home countries of Western European car manufacturers, in particular, in Germany, France and Italy (Calabrese, 2001). Despite a massive expansion of production capacities within Central and Eastern European low-wage countries, automotive companies have so far not built up larger R&D units in this region (Pavlinek, 2012). The globalisation of automotive companies has led to the emergence of regional R&D centres in Asia (China) and South America (Brazil), but CEE, which is an inner European low-wage region, has not benefited from this development.

The concentration of automotive R&D in Germany gives German manufacturing plants considerable advantages in the competition with low-wage locations about the assignment of lead plant roles. Lead plant roles entail responsibility for the introduction and ramp-up of new products and production technologies, and they require a particular cooperation between product development and the manufacturing areas (as well as the cooperation between manufacturing and other functions like planning, logistics, etc.). This cooperation extends from the first drawings of the product to series production, which was one of the core points discussed in the research about new product development (Clark and Fujimoto, 1991; Jürgens, 2000). Hence, design for manufacturing (Boothroyd *et al.*, 1993; Jürgens, 1999; Fujimoto, 2000) is an important issue in the early stages of product development, because it aims to develop products in a way that ensures their efficient production. This requires the introduction of manufacturing knowledge in the early phases of product development (Haddad, 2000; Jürgens, 2000). Cross-functional cooperation between product development and manufacturing continues after product development in a narrow sense is completed. The ramp-up process of a new product encompasses several phases (see Winkler *et al.*, 2007; Surbier *et al.*, 2014): (1) the conception and planning of the production processes, as well as the production and purchasing of the required production equipment and tools, (2) preproduction, during which production technologies and processes are tested, and (3) the ramp-up of series production, which ends as soon as the plant produces at full capacity and reaches the required quality and productivity levels. Preproduction and product ramp-up are difficult phases; any problems that may still exist in terms of product specification and the manufacturability of the product are uncovered at this stage. These phases also bring to the fore any remaining problems with the design of the production processes and the functioning of production technologies. Supply chains have to be established, tested and optimised. All this requires close cooperation between the various manufacturing areas and planning, logistics and product development. Product development units need information from manufacturing about necessary adaptations to the product design; the planning departments have to optimise the production processes together with manufacturing and the equipment manufacturers.

Mastering the product ramp-up requires particular competencies, knowledge and experience (Wolgast and Carlson, 2007; Fjällström *et al.*, 2009). The demands on employees are even greater when new production technologies are introduced. Therefore, companies can be expected to entrust the implementation of new product technologies to plants that have particularly experienced staff. Differences in labour-use strategies between German and CEE plants might hence be the result of an uneven distribution of lead plant roles. This leads to the third hypothesis:

H3: The extent to which a workplace plays a leading role in the introduction of new process technologies influences the relationship between production technology (automation) and skill requirements. Given the same level of automation, plants responsible for the testing and implementation of new production technologies will have higher vocational skill requirements than plants without such a role.

**Data**

The data used in this article were collected in the research project 'Perspectives of the Automotive Supplier Industry' conducted by Martin Krzywdzinski and Axel Schröder (WZB), Martin Schwarz-Kocher and Heinz Pfäfflin (IMU Institute), and Inger Korflür and Ralf Löckener (Sustain Consult) in 2015–2016. The project was funded by the Hans Böckler Foundation.

The project included a survey of employee representatives (works councils in Germany, workplace trade union chairpersons in CEE) and eight case studies of automotive suppliers conducted by the WZB team. Adopting a mixed methods approach, the analysis in this article uses both quantitative survey data and the qualitative case studies.

In total, 145 employee representatives from German plants and 125 employee representatives from CEE plants (Poland, Czech Republic, Slovakia and Hungary) participated in the survey. One of the survey questions addressed the degree of automation in the plants, which was measured using a 5-point scale (strongly automated production, predominantly automated production, mixed production, predominantly manual production and completely manual production). For the analysis in this article, only plants with strongly or predominantly automated production were selected. This corresponds to 75 plants in Germany (53 per cent of all respondents) and 25 plants in CEE (20 per cent of all respondents).

Since a one-dimensional scale was used to measure automation, the data do not distinguish between conventional high automation and the new approaches discussed in concepts like *Industrie 4.0*. The case studies (see below) show that highly automated automotive supplier factories combine both types. The bulk of the equipment consists of conventional automated welding lines, pressing lines, CNC machines and others. Frequently, however, first—and usually small—experimental projects related to the introduction of lightweight robots, the Internet of things, and other new elements of automation can be found in the companies under study.

The higher share of highly automated automotive supplier plants in Germany compared to CEE could be interpreted as an indicator that plants in low-cost regions still specialise in manual production. This is only partially the case. As the case studies show (Krzywdzinski, 2016), most CEE plants report mixed production, which includes both highly automated and manual areas. The reason for this constellation is the product mix in CEE plants. Most automotive suppliers have shifted small series production (volumes of around 20,000 pieces and below) that cannot be produced profitably on automated lines to CEE. However, since the survey does not allow to distinguish between different areas within the plants, the analysis excluded plants with mixed production from the analysis and focused on predominantly or strongly automated plants.

The plants included in the analysis belong overwhelmingly to multinational supplier corporations. Plants operated by local companies without operations in other countries represent a small minority (five plants in Germany, two in CEE). Table 1 presents basic information about the plants. As it shows, the sample includes plants operated by companies from different countries of origin and operating in different product segments of the automobile supply industry.

In addition, eight case studies were conducted in automotive supplier companies, focusing on the division of labour between German and CEE plants (in the following analysis, they are labelled A to H). The case studies involved companies of different sizes (ranging from around 10,000 employees in total to huge conglomerates with more than 150,000 employees worldwide) operating in different product areas (engine components, body structure, powertrain, interior and electronics). Four of the case studies included one German and one CEE plant operated by one company and producing mostly similar products. Four other case studies were limited to a single CEE plant. All case studies encompassed a plant visit including several one-to two-hour interviews with management and union representatives, as well as a plant tour. Typically, a plant visit involved interviews with the plant manager, the production manager, the HR manager and employee representatives. In total, 46 interviews were conducted.

The fact that the survey relied on information from employee representatives in the plants not only has some advantages but also some limits. Skill requirements and employment conditions (the use of fixed-term contracts and temporary agency work) are issues of high importance to employees, and employee representatives are usually

*Table 1: Basic information about company sample (survey)*

| | Germany | CEE |
|---|---|---|
| Number of plants | 75 | 25 |
| *Number of employees* | | |
| Average | 1,224 | 1,277 |
| Minimum | 80 | 150 |
| Maximum | 9,000 | 4,500 |
| *Company's country/region of origin* | | |
| Germany | 47 (62.7%) | 8 (32.0%) |
| Western or Northern Europe | 12 (16.0%) | 5 (20.0%) |
| Central or Eastern Europe | 4 (5.3%) | 2 (8.0%) |
| Northern or Southern America | 8 (10.7%) | 9 (36.0%) |
| Asia | 4 (5.3%) | 1 (4.0%) |
| *Product area (multiple selections possible)* | | |
| Body/exterior | 19 (25.3%) | 5 (20.0%) |
| Body structure | 18 (24.0%) | 3 (12.0%) |
| Chassis | 16 (21.3%) | 5 (20.0%) |
| Powertrain | 22 (29.3%) | 12 (48.0%) |
| Engine and aggregates | 38 (50.7%) | 10 (40.0%) |
| Interior | 14 (18.7%) | 8 (32.0%) |
| Electronics | 28 (37.3%) | 6 (24.0%) |

*Source:* Krzywdzinski *et al.*, 2016. Only automotive supplier plants with predominantly or strongly automated production.

quite well informed about them. These employee representatives usually also have good information regarding the role of their plant in the introduction of new products and production technologies—simply because such processes are highly visible and important for a plant's long-term development. There are, however, also limits to the data used here. Plant-level employee representatives are not always well informed about the company's overall strategy. If, for instance, a manufacturing plant relies heavily on unskilled labour, this might be due to a deliberate 'low road' strategy or it may simply be the result of the external conditions in a country with a weak vocational education system that does not provide enough skilled workers for the needs of the company. The survey data do not provide direct information about the motives behind a certain labour-use strategy—they have to be analysed through a multivariate analysis. The case studies, which were mainly based on interviews with management, provide an additional opportunity to check the plausibility of the survey results.

An important advantage of the employee-representative survey used here is that it allows overcoming a lack of (establishment level) data about automation, skill requirements and the use of agency work in official statistics and databases.

The analysis in this article will use the variables specified in Table 2. Labour-use strategies are operationalised through variables focusing on skill requirements and employment conditions. Skill requirements are analysed using three variables indicating the share of production jobs requiring one week of training, six months of training and a full, multi-year vocational education. All three are ordinal variables coded with a 5-point scale (see Table 2). An additional three variables are used to examine employment conditions. Two ordinal variables (7-point scale) measure the share of fixed-term contracts and temporary agency workers. A continuous variable measures labour turnover in the plants.

*Table 2: Descriptive statistics of variables used in the analysis (survey)*

| Variable | Scale | Obs | Median | Min | Max |
|---|---|---|---|---|---|
| Share_1week_jobs | 1 = '0–19%', 2 = '20–39%', 3 = '40–59', 4 = '60–79%', 5 = '80–100%' | 98 | 1 | 1 | 5 |
| Share_6months_jobs | | 98 | 2 | 1 | 5 |
| Share_vet_jobs | | 97 | 2 | 1 | 5 |
| Share_fixed | 1 = '0–5%', 2 = '6–10%', 3 = '11–15%', 4 = '16–20%', 5 = '21–25%', 6 = '26–30%', 7 = '>30%' | 97 | 2 | 1 | 7 |
| Share_agency | | 98 | 2 | 1 | 7 |
| Labor_turnover | Continuous variable | 76 | 2 | 0 | 46 |
| Org_degree | Continuous variable | 94 | 41.2 | 0.3 | 100 |
| Lead_plant | 1 = 'Always/often', 2 = 'Sometimes/partially', 3 = 'Seldom/never' | 91 | 2 | 1 | 3 |
| Country | Categorical variable: 1 = Germany, 2 = Poland, 3 = Czechia, 4 = Slovakia, 5 = Hungary | 100 | – | – | – |

The national institutional frameworks are included into the analysis in the form of the group variable 'country'. By using the country variable, the analysis avoids treating the CEE countries as homogeneous. The data set has a hierarchical structure: plants are nested in countries (Germany and the four CEE countries). In order to take this into account, a two-level mixed-effects model will be applied in the following. It takes the hierarchical data structure into account by calculating country-specific intercepts of the regression lines. As the model includes ordinal variables, a mixed-effects ordered logistic regression was applied using Stata's meologit procedure (cf. Rabe-Hesketh and Skrondal, 2005).

The power of employee representatives is operationalised as the degree of unionisation, that is, the proportion of employees who are union members. The lead role of a plant in the introduction of new production technologies is measured using the item 'New production technologies are introduced in our plant first,' with three response options ('always/often,' 'sometimes/partially' and 'seldom/ never').

**Do labour-use strategies in Germany and Central Eastern Europe differ?**

The comparison between CEE and German plants yields evidence of very different labour-use strategies in both regions. The survey included a question about the proportion of production jobs requiring (1) a one-week introduction only (simple, unskilled jobs), (2) a six-month training period (semi-skilled jobs) and (3) a multi-year vocational education. Bear in mind: the following analysis focuses on plants with strongly or predominantly automated production only.

Figure 1 shows the distribution of answers to questions concerning simple, unskilled jobs. While they represent a small share (median 0–19 per cent) of production jobs in German plants, they comprise around half (median 40–59 per cent) of all production jobs in Central and Eastern European plants. Employee representatives from one-third of CEE plants even report a share of unskilled jobs above 60 per cent.

The analysis of production jobs requiring up to six months of training is skipped in the following because there is no statistically significant difference between German and CEE plants (very similar distribution of responses, Mann–Whitney test $p$ = 0.3006). In contrast, in the case of production jobs requiring a multi-year vocational education, the differences are clear (Figure 2). While in German plants, these jobs represent an average of (median) 40–59 per cent of all production jobs, the median in CEE plants is 0–19 per cent! Jobs with high-skill requirements constitute a small minority in CEE

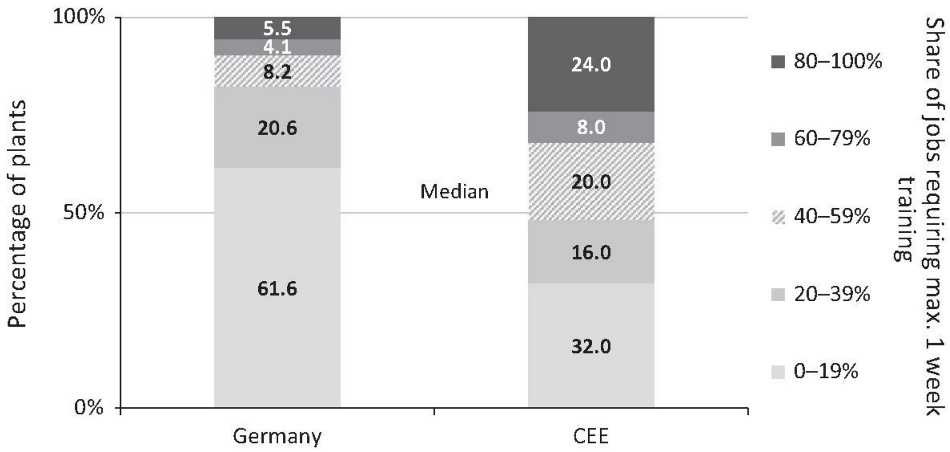


*Figure 1: Production jobs requiring max. one-week training (Germany and CEE). Mann–Whitney test* p *= 0.0016. Automotive supplier plants with predominantly or strongly automated production*

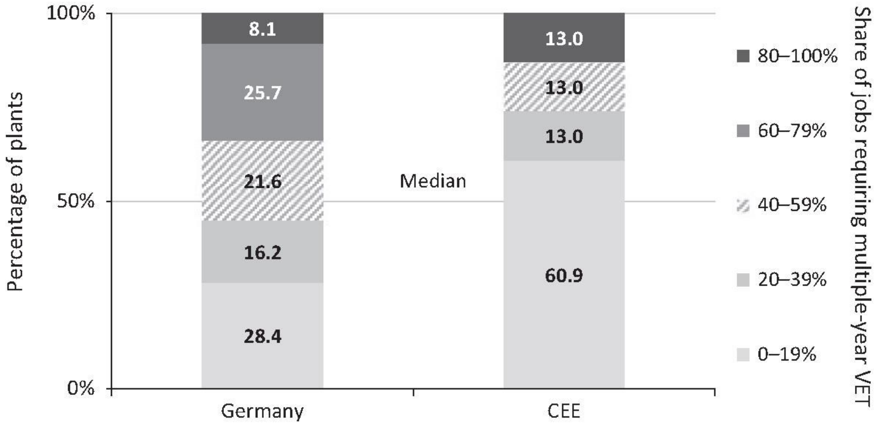


*Figure 2: Production jobs requiring a multi-year vocational education (Germany and CEE). Mann–Whitney test* p = *0.0118. Automotive supplier plants with predominantly or strongly automated production*

plants, while they represent a majority in German plants—although only highly automated plants in both regions are considered.

The differences in skill requirements correspond to different employment conditions. As Figures 3 and 4 show, CEE plants use fixed-term contracts, and temporary agencies work much more frequently than their German counterparts. The median use of fixed-term contracts is at 6–10 per cent in CEE plants; more than 40 per cent of CEE plants report that more than 15 per cent of their contracts are fixed-term contracts. This reflects a common practice in CEE of relying on chains of fixed-term contracts over many years (Prosser, 2016). In German plants, the median use of fixed-term contracts stands at 0–5 per cent; only 15 per cent of German plants report a proportion of fixed-term contracts above 15 per cent.

The median share of temporary agency work in total employment is 6–10 per cent in (highly automated) plants in both Germany and CEE. However, differences between the regions remain. In CEE, the share of plants extensively using temporary agency work is considerably higher. More than 35 per cent of CEE plants employ at least 15 per cent of all staff as temporary agency workers, compared to around 12 per cent of German plants.

The differences in skill requirements and employment conditions are linked to differences in labour turnover. In the highly automated plants in CEE studied here, the average labour turnover was 10 per cent; in the German plants it was around three per

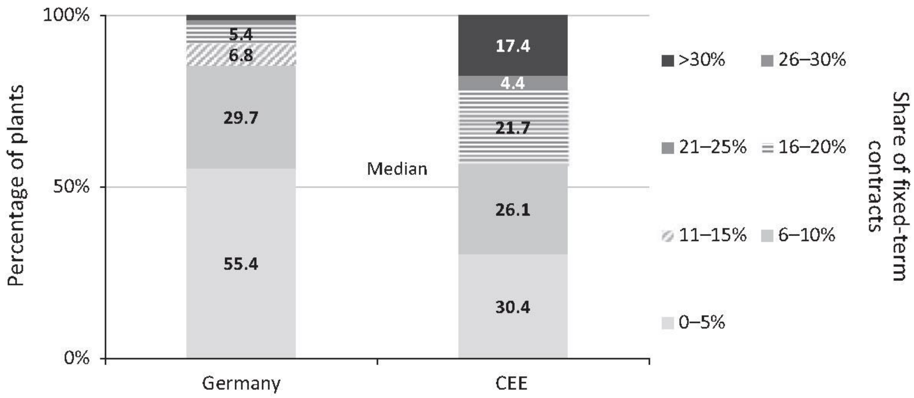


*Figure 3: Share of fixed-term contracts (Germany and CEE). Mann–Whitney test* p = *0.0032. Automotive supplier plants with predominantly or strongly automated production*

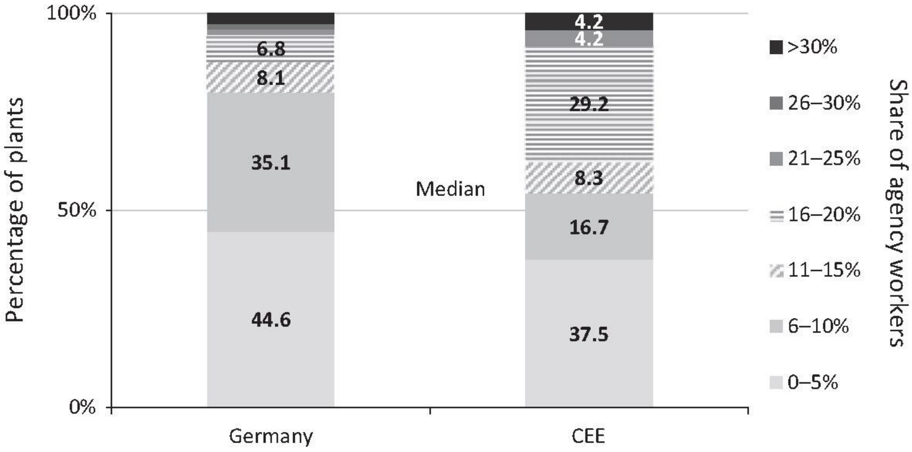


*Figure 4: Share of temporary agency workers (Germany and CEE). Mann–Whitney test p = 0.1062. Automotive supplier plants with predominantly or strongly automated production*

cent. For the quartile of plants with the highest labour turnover, values ranged between 4 per cent and 15 per cent in Germany, but between 10 per cent and 46 per cent in CEE!

The findings from the survey are confirmed by the case studies. Management at the CEE plants emphasised the low-skill requirements for rank-and- file production workers. An internal introductory training course lasting a few weeks was considered sufficient to master the first job, and a training period of several months was enough to achieve the polyvalence required in the team. This applied to different production processes like foundry (cases A, F), welding (cases B, D, E) or machining (cases A, C, D, E, F).

Vocational skills are irrelevant for production workers. When we're talking about vocational education, we're talking about maintenance, tool making, or process engineers.

(Interview 2D2)

A worker operates five or six machines. In principle, he learns his tasks on the job. Motivation to learn and responsibility are important. Sure, a skilled worker with a vocational qualification who has learned to work with CNC will learn how to operate a new machine much more quickly. But in principle, everybody can learn it.

(Interview 1M1)

In the case studies, the foundation for this pattern was a rigid division of labour on the shop floor between:

• Direct workers: Unskilled and semi-skilled workers were responsible for the provision of material, the insertion of parts into machines, the operation of machines and small maintenance tasks like the exchange of sensors. Team leaders and setters, who were usually recruited from the workers and received additional training, were responsible for the setting of the machines (changing parameters) and minor problem-solving tasks.

• Indirect employees: Engineers programmed machines and adapted programms; when machines broke down, repair was completed by the maintenance department, where skilled workers were in the majority.

Indirect employees were responsible for regulation tasks, while direct production workers were restricted to operating tasks. This division of labour was often combined with highly standardised direct production work and the use of visualisation tools to ensure high quality and process stability even with a large share of unskilled workers.

**Explaining the differences**

The first step is a simple bivariate analysis of the dependent and independent variables (Table 3). Dependent variables include the share of production jobs requiring a vocational education certificate, the share of temporary agency workers in total employment and the share of fixed-term contracts in total employment. Other variables indicating skill requirements on the shop floor (e.g. the share of production jobs requiring only one week's training) show similar results and are not presented here.

The country variable shows a statistically highly significant relationship with skill requirements on the shop floor—regardless if a categorical variable including all the individual countries or a dummy variable with 1 for Germany and 0 for CEE is used. The relationship between country and the share of temporary agency workers in total employment is less clear, but it approaches the 0.05 significance level when the version with all five individual countries is used. There is also a statistically significant relationship between country and the share of fixed-term contracts. The lead role for new production technologies shows a moderate relationship with the share of jobs requiring vocational education (<0.1 significance level). There is no significant relationship with the share of temporary agency workers and fixed-term contracts. In the case of the degree of unionisation, there is no statistically significant relationship with neither of the variables.

This suggests that institutional differences and establishment-level characteristics regarding the lead role for the introduction of new production technologies might be better explanations for labour-use strategies than the power of employee representatives. The question is, does a multivariate analysis confirm this result?

A multivariate test of the three initial hypotheses was conducted using a mixed-effects ordered logistic regression. Table 4 shows the results, with the share of production jobs requiring a completed vocational education as the dependent variable. Four versions of the model were calculated. The first baseline model includes only control variables (employment size, home country of the company, product segment). The second model includes country as the group variable, the third one adds the degree of unionisation and the fourth one adds the lead plant role. The degree of unionisation does not even reach the 0.10 level of statistical significance, and it increases the $R^2$ of the complete model only marginally. There is a positive relationship between a lead plant role and the share of production jobs requiring vocational education; it is significant at the 0.10 level, but given the low number of cases (which limits the attainable significance levels), it is accepted as an indicator of an existing relationship. Both country (group variable) and the lead plant role variable contribute to the $R^2$ of the complete model by a similar amount.

*Table 3: Bivariate analysis*

| Independent variables | Test | Dependent variable: share_vet_jobs | Dependent variable: share_agency | Dependent variable: share_fixed |
|---|---|---|---|---|
| Country dummy (Germany-CEE) | Mann–Whitney | $p = 0.0118$ | $p = 0.1062$ | $p = 0.0032$ |
| Country (all five countries) | Kruskall–Wallis | $p = 0.0187$ | $p = 0.0540$ | $p = 0.0061$ |
| Lead_plant | Spearman | $r_s = 0.1974$, $p = 0.0653$ | $r_s = -0.0874$, $p = 0.4151$ | $r_s = -0.0986$, $p = 0.3608$ |
| Org_degree | Spearman | $r_s = 0.1245$, $p = 0.2398$ | $r_s = -0.0770$, $p = 0.4609$ | $r_s = -0.1514$, $p = 0.1474$ |

Automotive supplier plants with predominantly or strongly automated production.

*Table 4: Mixed-effects ordinal logistic regression (dependent variable: share_vet_jobs)*

| | Baseline model | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | Coef (std. err.), *p* value | | | |
| Country (group variable) | | Included | Included | Included |
| Org_degree | | | 0.0029 (0.0112), 0.797 | 0.0125 (0.0112), 0.264 |
| Lead_plant | | | | 0.5831 (0.3532), 0.099 |
| Var (constant) | | 0.7646 (0.8744) | 0.6802 (0.8433) | 0.0000 (0.0000) |
| Pseudo $R^2$ | 0.0377 | 0.0510 | 0.0542 | 0.0733 |
| $Chi^2$ test vs. standard logistic regression | | 0.0292 | 0.0633 | 0.3589 |
| *N* | 89 | 89 | 88 | 81 |

Controls included in all models for employment size, home country/region of the company, and product segment. Automotive supplier plants with predominantly or strongly automated production.

A similar multivariate model was calculated using the share of temporary agency workers in total employment as the dependent variable (Table 5). It also included the share of production jobs requiring vocational education among the independent variables. It proves to be the most important factor: It is responsible for the highest share of $R^2$ of the complete model and is statistically significant at the 0.001 level. With this variable included, union power and lead plant role show no statistically significant impact on the share of agency workers.

The picture changes when the same multivariate model is calculated using the share of fixed-term contracts in total employment as the dependent variable (Table 6). Skill requirements, the power of employee representatives and the lead plant role exhibit no statistically significant impact on this dependent variable. Apart from the control variables, country (the group variable) is the only variable to have a statistically significant impact; it also contributes most to the $R^2$ of the complete model.

The findings from the qualitative case studies can be used to check the plausibility of the quantitative analysis. The case studies showed a clear relationship between lead plant role and skill requirements on the shop floor. In two cases (C and D), the German plant not only performed production work but also had a huge R&D unit and a tooling/ equipment-manufacturing shop. In both cases, this was the main reason why the plants were assigned the lead role for the implementation of new technologies. Case D is used in the following to illustrate these relationships. The German plant D-DE is the location of the main production development unit for the products that are manufactured in the plant. The company also decided to build the pilot hall (prototype building) and the equipment-manufacturing site in direct proximity to R&D. The equipment shop produces the welding tables and transport systems for the company's own needs. The presence of R&D, prototype building and equipment manufacturing in one place makes the D-DE plant the preferred location for trying out new technologies before they are implemented abroad. A central unit responsible for process design, preproduction and preparation of series production was created in the plant; it is responsible for supporting other plants during the introduction of new products and technologies. However, the plant manager at D-DE expects foreign plants to increasingly take on

*Table 5: Mixed-effects ordinal logistic regression (dependent variable: share_agency)*

| | Baseline model | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| | Coef (std. err.), *p* value | | | | |
| Country (group variable) | | Included | Included | Included | Included |
| Share_vet_jobs | | | −0.6334 (0.185), 0.001 | −0.6232 (0.1869), 0.001 | −0.7866 (0.2122), 0.000 |
| Org_degree | | | | −0.0104 (0.0111), 0.349 | −0.0099 (0.0110), 0.365 |
| Lead_plant | | | | | 0.3288 (0.3835), 0.391 |
| Var (constant) | | 0.7851 (0.8718) | 1.1299 (1.4718) | 1.2490 (1.5903) | 0.0000 (0.0000) |
| Pseudo $R^2$ | 0.0618 | 0.0742 | 0.1289 | 0.1280 | 0.1411 |
| $Chi^2$ test vs. standard logistic regression | | 0.0356 | 0.1402 | 0.1368 | 0.0000 |
| *N* | 92 | 92 | 89 | 88 | 81 |

Controls included in all models for employment size, home country/region of the company, and product segment. Automotive supplier plants with predominantly or strongly automated production.

more responsibility for the ramp-up of new products and production technologies themselves. At the time of this study, such self-reliance was not yet in evidence. The works council at D-DE linked this lack of skills in CEE to the inadequate vocational education programmes and the low pay levels. The D-CEE plant included in the study did not actually offer any vocational education schemes. The German works council described the need to support other plants during the introduction of new products and technologies as a huge burden for D-DE, which was not fully understood by the company's management:

We send our employees abroad for months; these are welders, equipment operators, electricians, or maintenance specialists. Even our plant directors go abroad from time to time in order to support the others. […]

*What about the future? How long will it take for the other plants to take on responsibilities for the ramp-up of new products and the introduction of new technologies?*

They should already be doing it now, but it's not working and it will not work, because they lack the skills. They don't have any vocational education programs in the plants in CEE. Even if they find someone with the required skills on the labor market—for instance, someone who knows PLC (programmable logic controller)—they are not able to keep him for long. These kinds of people want to earn more than what we are paying in CEE. Our plants survive as low-cost locations only because they get help from our German plants. If they wanted to hire the skilled staff they actually need, they would have to pay much more.

(Interview 4D1)

*Table 6: Mixed-effects ordinal logistic regression (dependent variable: share_fixed)*

| | Baseline model | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| | Coef (std. err.), *p* value | | | | |
| Country (group variable) | | Included | Included | Included | Included |
| Share_vet_jobs | | | −0.0350 (0.1677), 0.835 | −0.0132 (0.1710), 0.938 | −0.0534 (0.184), 0.772 |
| Org_degree | | | | −0.0162 (0.0110), 0.144 | −0.0116 (0.0115), 0.316 |
| Lead_plant | | | | | 0.0460 (0.4193), 0.913 |
| Var (constant) | | 0.6119 (0.6615) | 0.5585 (0.6431) | 0.3830 (0.5698) | 0.8823 (0.9327) |
| Pseudo $R^2$ | 0.0719 | 0.0849 | 0.0804 | 0.0899 | 0.0967 |
| Chi² test vs. standard logistic regression | | 0.0395 | 0.0658 | 0.1904 | 0.0458 |
| *N* | 91 | 91 | 89 | 88 | 81 |

Controls included in all models for employment size, home country/region of the company, and product segment. Automotive supplier plants with predominantly or strongly automated production.

There was no clear evidence regarding the union power factor. In all of the in-depth case studies, German works councils were urging management to invest in vocational education programmes, while this was not the case in CEE. It is hard, however, to determine the impact of these efforts on job design on the shop floor, and to isolate them from other factors. In cases C and D, management and works councils agreed on the required vocational skills; this agreement was based on the technological lead role of German plants described above. In the other cases, the efforts of works councils were directed towards enforcing existing commitments, that is, implementing collective agreements regarding the number of apprentices taken on and the hiring of these apprentices following completion of their training.

**Discussion and conclusions**

The analysis shows that very different labour-use strategies are deployed in highly automated factories in the automotive supplier sector. The labour-use strategy in the German plants focuses on vocational skills, while the CEE plants are characterised by a much greater reliance on semi-skilled work combined with a higher share of precarious employment relationships and higher labour turnover.

Given that the analysis only included plants with a high automation level, the differences in labour-use strategies cannot be explained by technological differences. The analysis has aimed to discuss three potential explanations: the role of national institutional settings, the role of employee representative power and the role of the plants in introducing new production technologies.

The evidence is weakest regarding hypothesis H2 about the influence of employee representatives on labour-use strategies. The data and analysis do not provide evidence for this relationship. It is necessary to take into account, however, that the number of plants included in the analysis is relatively small and that there is a potential selection bias. The survey included unionised plants only and used the degree of unionisation as an indicator for union strength. The analysis may have got more definitive results if the survey had included completely non-unionised plants.

In contrast, the data support both the hypothesis related to the role of national skill formation regimes and the hypothesis related to the role of the establishments regarding the introduction of new production technologies. The country variable was statistically significant in nearly all examined models (H1). This suggests that plants adapt to the national labour market situation. In labour markets with a substantial supply of highly skilled blue collar workers (like the German one), they design their production systems so as to make use of these skills. In labour markets (like the CEE ones) characterised by a lack of highly skilled blue collar workers, firms turn to low-cost labour-use strategies.

Besides the country, the data show that establishment-level characteristics are also influencing labour-use strategies. The core relationship is between the role of a plant in the introduction of new technologies and skill requirements. It is not only automation per se that leads to high skill requirements in production, but also the role of a plant in the roll out and ramp-up of new products and new process technologies (H3). Such a role requires close cooperation between employees in the manufacturing areas and those from product development, the equipment manufacturers, and further functions (logistics, supplier relations, etc.). For production workers, such cooperation requires a long and intensive vocational education linking theoretical knowledge and practical skills. Higher skill requirements related to a plant's lead role in new technologies results, in a second step, in a lower use of temporary agency work. The share of fixed-term employment contracts, in contrast, is mainly determined by national regulations, while there is no impact of the plant's role in the value chain. The permissive regulations in CEE give the factories located there more leeway to use fixed-term contracts.

In addition, the country where a plant is located and the plant's probability of having a lead role in implementing new technologies are strongly correlated. 55 per cent of the German plants included in the survey report that they have a lead role in implementing new technologies (meaning that they always implement new production technologies first, before they are rolled out in other plants); in CEE, only nearly 23 per cent of plants report having such a role.

This article's main theoretical contribution to the debate about the relationship between technology and skills is to introduce a new and important concept, namely the role of the factory within the whole company and the value chain, and, in particular, the role of the factory in the introduction of new products and technologies. The current debate in economics assumes a clear and universal relationship between automation and skill requirements (Frey and Osborne, 2013; Brynjolfsson and McAfee, 2014; OECD, 2017), which might be modified by policy interventions (for instance, influencing factor prices), while recent sociological literature has emphasised the role of workplace politics (Edwards and Ramirez, 2016; Hirsch-Kreinsen, 2016). The analysis presented in this paper supports the sociological arguments about the importance of workplace-level factors for the relationship between automation and skills. It, however, places less emphasis on micro-level workplace politics and more on the role of the plant in the value chain and the international division of labour. Whether an upskilling or deskilling trend can be observed in a plant thus depends to a considerable extent on its role in the value chain.

One important consequence of this argument is that automation processes should not be expected to have similar outcomes in different countries and locations. This can be exemplified by looking at new production techniques discussed in *Industrie 4.0,* and similar programmes. It is very likely that these new concepts will first be introduced in high-wage locations situated near the main R&D facilities and equipment manufacturers. The plants that introduce these technologies first will probably experience an upskilling trend for the manufacturing workforce (which might also entail the loss of low-skill jobs) due to the need to cooperate with R&D, planning, process engineering, etc. It is far from certain, however, that the same upskilling scenario will be observed once the new production concepts have been established and mastered, and are being implemented in other locations. The experience from CEE teaches that high automation is compatible with a high share of semi-skilled workers and precarious employment relationships—and this could also apply to 'new' technologies in the future (Howcroft and Taylor, 2014: 1).

A second important consequence of the analysis presented in this paper relates to the strategies of employee representatives and workers facing the introduction of new automation concepts. In a recent paper, Edwards and Ramirez (2016) discuss 'when should workers embrace or resist new technologies.' Their argument focuses on the characteristics of the technology and gives the workers two strategic options: embrace or resist. This represents, however, a very short-term perspective. The analysis presented here shows that, in the long run, employee representatives (and workers) should focus on the role of the plant in the value chain because this influences the impacts of new production technologies. This implies much more strategic options than Edwards and Ramirez suggest. The core issue is how to convince (and force) the management to invest in new plant capabilities. This might include resistance to some management measures (in particular, to those which point in the direction of low-cost solutions), but it may also prompt the development of potential compromise solutions aiming at developing innovative forms of work organisation, expertise with certain technologies etc.

The data and analysis presented here have, of course, certain limits. Regarding all the variables included, the direction of the causal relationship is not always clear. While there are good reasons to argue that a plant's lead role in the implementation of new technologies pushes management to place more emphasis on vocational skills on the shop floor, the relationship might also function the other way around: A high share of skilled workers on the shop floor might make it easier for management to assign a plant the lead role for implementing new technologies. A further limit is that the survey used here relies on employee representatives only. An important goal for future research will be to develop more comprehensive and multi-source data.

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